POWER PLANT ENGINEERING

Established Over 33 Years

VOL. XXXIII CHICAGO, MARCH 1, 1929 No. 5

EDITORIAL STAFF — ARTHUR L. RICE, Editor; R. E. TURNER, Managing Editor; A. W. KRAMER, Associate Editor; CHESTER R. EARLE, Associate Editor; RICHARD H. MORRIS, Associate Editor; EDWARD J. KUNZE, Associate Editor

Contents of this Issue

Page

Holland Station Design Embodies 1200 Lb. Pressure..... 282

How Good Water is Secured for a Blast Furnace Plant. By T. J. Ess..... 288

Keep the Turbine Governor in Good Condition..... 292

Interlocking Coal Handling Equipment. By C. O. Von Dannenberg 294

Comparison of Oil Engine Performances. By Otto Nonnenbruch 295

Industrial Plant Transformer Installations. By E. Ogur.. 297

Design and Operation of Generator Air Coolers. By E. Wainwright Johnston 299

Electricity—What It Is and How It Acts. By A. W. Kramer 301

Burning Colliery Waste in Pulverized Form..... 304

United Electric Light Co. Completes Indian Orchard Plant 305

Manufacture of Carbon Dioxide Snow. By N. H. Hiller.. 306

Gas Used for Fuel at Lake Pauline Station..... 308

Pulverized Coal—How Fine? By H. G. Lykken..... 312

A. I. E. E. Winter Convention Brings Out Many New Developments 314

Letters Direct from the Plant: Centrifugal Pump Handles Hot Water Successfully. Relation Between M. E. P. and Engine Speed. Outside Storage of Coal. Peculiar Treatment Makes Bearing Run Cool. "I Made It Myself." Sprinkler Made of Old Pipe Fittings. Oil Mixed with Clay Prevents Explosion..... 317

Questions and Answers: Stack Computation. Predetermining Temperature of Reduced Pressure Steam. Boiler Operation. Problems Encountered by Boiler Operator. Pump Size and Condenser Action..... 320

Editorial Comment: That Elusive Income. Something New Under the Sun. Extra! Purchasing Agents Have Ethics. Interchangeability and Costs..... 322

Masters of Power Discuss Progress of the Industry..... 324

Six Companies Joined in North American Refractories.... 326

Riflex Mechanical Drive for Stokers..... 327

Kennedy-Van Saun Burners..... 327

Type G K Diaphragm Meter..... 328

Circuit Breaker for Moderate Capacities..... 329

Copes Type D S Pump Governor..... 329

Combination Automatic Backstop and Flexible Coupling.. 329

Orton 5/8 Yd. Convertible Shovel..... 330

Lab-Rette for Water Testing..... 330

Lowboy and Highboy Unit Heaters..... 331

Dissolved Oxygen Recorder for Boiler Feedwater..... 331

News Notes 332

Books and Catalogs..... 334

Power Plant Construction News..... 336

Published on the 1st and 15th of each Month by the

Technical Publishing Co., 53 West Jackson Blvd., Chicago

New York Office, 171 Madison Avenue

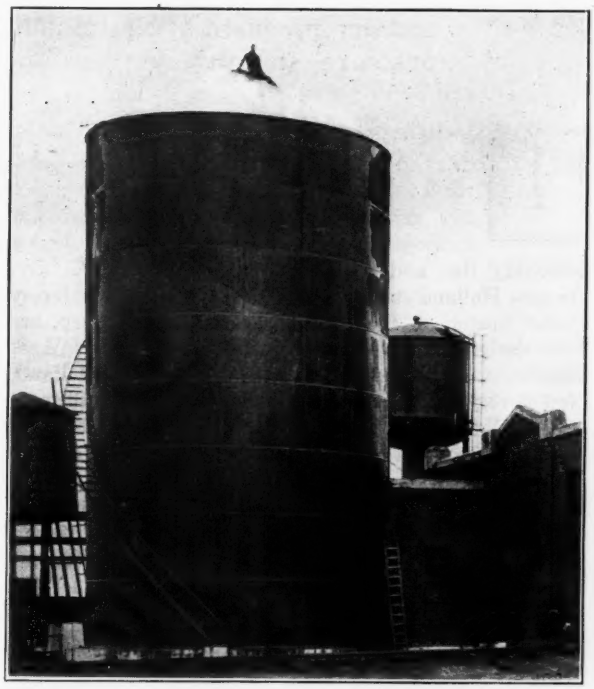
Subscription price $2.00 a year in the United States and possessions. Canada $2.75 a year. Other countries $3.50 a year. Single copies 15 cents.

Copyright 1929, by Technical Publishing Co.

Entered as second class matter May 1, 1908, at the Post Office at Chicago, Illinois, under the act of March 3, 1879.

Member, Associated Business Papers, Audit Bureau of Circulations.

Circulation of this issue 23,900



Einstein Tries His Riemann Curvature

LOOK AT THE MAN sitting on nothing! Indeed, so he is, or at least so it seems, but don't fool yourself. He isn't sitting on nothing—he is sitting on his Riemann curvature.

This is a picture of Prof. Einstein trying out the effect of his Equation 6 which as you know is as follows:

$$A^{\sigma}_{i\tau\cdots/i} = A^{\sigma\cdots i}_{\tau\cdots,i} + A^{\alpha\cdots i}_{\tau\cdots\Delta^{\sigma}_{\alpha i}} \cdots - A^{\sigma\cdots i}_{\alpha\cdots\Delta^{\alpha}_{\sigma i}} \cdots$$

Without taking a second look, you will readily see how easily a person could go up in the air over this equation; nevertheless, it is interesting to see an actual photograph of the effect. This photograph was sent to us with an article on water softening, by Mr. Ess, which appears in this issue, but of course it has nothing to do with water softening—Mr. Ess must have got his photos mixed. We recognized it at once as a picture of the professor himself doing a "falling leaf" along an unsymmetrical tensor of the Riemann curvature. This, of course, may not be obvious to many of our readers since there are only 12 people in the world who can understand it. Six of these, by the way, are on our editorial staff but we seldom mention this to anybody. While the stunt shown in the photograph looks easy, we wish to caution anyone against attempting it unless he can master the above equation. You might fall down an' go boom.

Holland Station Design for 1200 lb. Pressure

Analysis by Barstow Engineers of reasons for adoption of type and arrangement of equipment to be used in first 1200-lb. steam pressure station ever designed for variable load operation

IN ORDER TO TAKE care of increasing demand and insure best service over a territory which now extends continuously about 250 mi. from northern Maryland through Pennsylvania to the northern New Jersey boundary line and within 30 mi. of New York City, the new Holland station of the Pennsylvania-New Jersey Power Station of the General Gas & Electric Corp. has been designed and is now being constructed by W. S. Barstow & Co., Inc., on the Delaware River at Holland, New Jersey. This station, which will have an ultimate capacity of 220,000 kw. and which will be initially supplied with a 55,000-kw. unit, will be the main eastern generating station of the system.

On the western end of the system, at Middletown, Pa., a modern economical station of 70,000-kw. present capacity, 210,000-kw. ultimate, is located and near the center of the system, a station of 70,000 kw. is located at Reading, Pa. With these three main generating stations, several hydro-stations and ample spare capacity in several smaller steam plants, the system provides a power reservoir capable of large expansion and of supplying continuous service on lately increased demands, as well as an interchange of power with neighboring power station systems.

Older Plant Acts as Pacemaker

Faced with the problem of creating a generating station which would better the results obtained at Middletown, which is an economical 350-lb. pressure plant receiving coal of the same quality as that which will be used at Holland but located in a lower freight-rate zone, the designers made careful detailed studies comparing 400-lb. pressure, no preheat, 2 and 3-stage extraction, with 550-lb. reheat and 1200-lb. reheat, both with 4-stage extraction. Fourth-stage extraction on 400-lb. pressure was not considered economically profitable, consequently it was not used in the comparison.

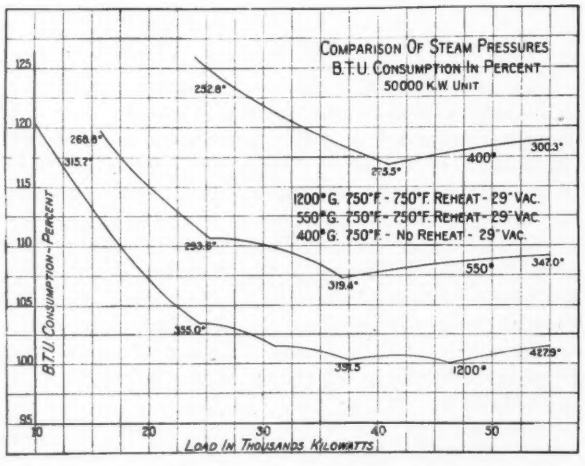


FIG. 1. COMPARISON OF B.T.U. CONSUMPTION OF VARIOUS PRESSURE SYSTEMS

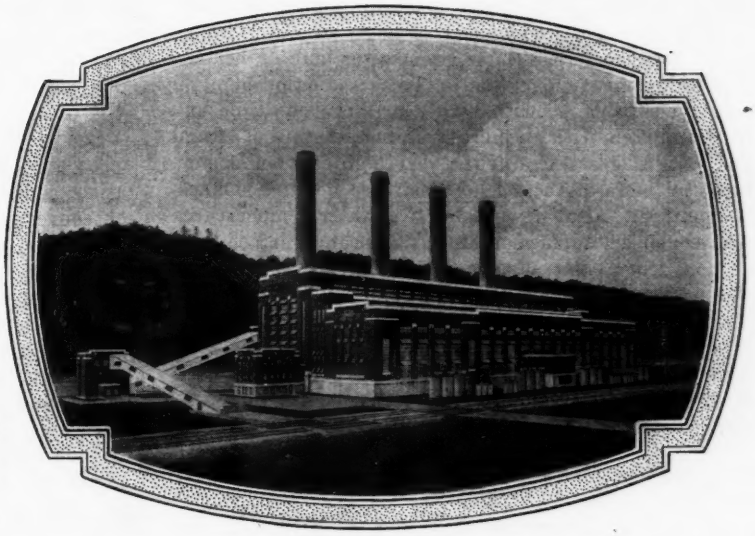
In considering the design, it was first necessary to determine as accurately as possible the load pressure at which the station would operate and keep in mind that coal would cost $5 per t. delivered, thus allowing a greater increase in investment per per cent betterment in economy than could be justified with coal costing less per B.t.u. It appears that the present trend throughout the country toward complete interconnection of the power stations of a single system and still further between systems of various companies, will have a decided tendency to increase the capacity factor, making it less and less necessary to install spare units as stations are constructed, thus materially reducing the investment required and increasing the active use of the equipment installed.

It appears also that the demand for electric power during and immediately after the late war caused greater percentages of growth than is to be expected in the near future. Also, the increase in economy between the old low-pressure, small unit plant and the present high-pressure, large unit plant, was probably greater than that which will be obtained in the near future for similar time intervals, above the plants now being designed. All things being considered, it seems that a 50 per cent capacity factor and 75 per cent operating factor would most nearly represent the load conditions.

Determination of Pressures

Economy data in B.t.u. consumption, for a 50,000-kw. turbine generator unit, were procured for the 400-lb. pressure, no reheat, and the 550-lb. and 1200-lb. single reheat cycles. Figure 1 shows these data in percentage of B.t.u. consumption with the 1200-lb. cycle used as 100 per cent for comparative purposes. These figures are based on an initial steam temperature of 750 degrees and exhaust to 29 in. of vacuum at all three pressures, with a reheat temperature of 750 degrees F. for the 550-lb. and the 1200-lb. pressures, with no reheat for the 400-lb. pressure.

n Embodies e Features



BUILDING TO HOUSE UNIQUE PLANT IS CHARACTERIZED BY ATTRACTIVE LINES, ABUNDANCE OF LIGHT AND CONVENIENCE FOR OPERATING STAFF

Detailed estimates on the first cost of the station designed for 400-lb., no reheat, 2 and 3-stage extraction, and 550-lb. reheat and 1200-lb. reheat, 4-stage extraction, were prepared and from these estimates the fixed charges were determined. When considering the fixed charges plus the production cost it appeared that the 550-lb. pressure reheat plant was less economical than the 400-lb. press. no reheat plant, because the saving in B.t.u. consumption of the former, was more than offset by the increase in fixed charges. The 550-lb. plant was also more expensive in both cost and B.t.u. consumption than the 1200-lb. plant. This study left but one conclusion, namely, that the station should be designed for either 400-lb. pressure or 1200-lb. pressure.

Conclusions drawn from careful estimates with different fuel costs are indicated in Fig. 2, which shows the fixed charge and fuel cost in mills per kw-hr., plotted against coal costs per ton. These curves indicate that the 400-lb. press., no reheat, 3-stage extraction cycle is the most economical with coal below $3.50 per t. and that with coal above this price. The 1200-lb. press., reheat, 4-stage extraction cycle is the most economical. The 55,000-kw. service used in the foregoing 550-lb. estimate, was the compound unit advised by the manufacturers. The conclusion drawn was that with coal costing $5.00 per t. delivered and a plant with 50,000-kw. turbine units having a capacity factor of approximately 50 per cent, the 1200-lb. reheat cycle is the most economical one when considering operating cost and fixed charges combined.

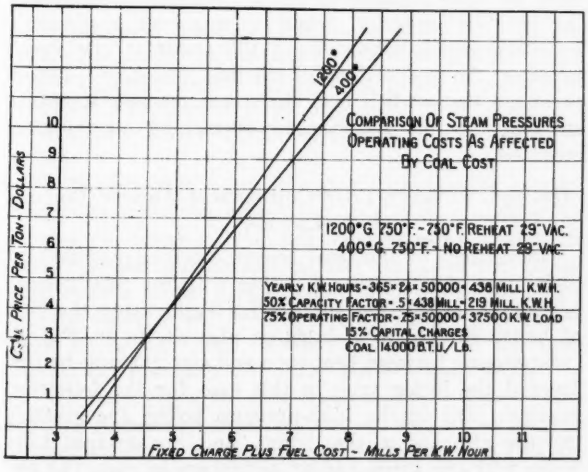

1200
400
Comparison Of Steam Pressures Operating Costs As Affected By Coal Cost
1200° G. 750° F. - 750° F. Reheat 29" Vac.
400° G. 750° F. - No Reheat 29" Vac.
Yearly K.W. Hours = 365 × 24 × 50000 × .438 Mill. K.W.H.
50% Capacity Factor - .5 × 438 Mill. = 219 Mill. K.W.H.
75% Operating Factor - .75 × 50000 = 37500 K.W. Load
15% Capital Charges
Coal 14000 B.T.U./Lb.
Coal Price Per Ton - Dollars
Fixed Charge Plus Fuel Cost - Mills Per K.W. Hour

FIG. 2. COMPARISON OF FUEL COSTS OF VARIOUS PRESSURE SYSTEMS

First Complete 1200-Lb. Plant

At the time the Holland Station was being designed, all 1200-lb. pressure installations in operation considered at that date were arranged as an increment to an existing fairly efficient station, thus allowing the high-pressure units to be operated upon base load conditions. In case of the Holland Station, however, where the new high-pressure station was being added to a system having one relatively large and several small hydro stations, as well as interconnections with neighboring systems largely depending upon hydro stations, largely fluctuating load conditions were expected.

It was advisable, therefore, to consider a design comprising equipment satisfactory for variable load operation. The first step necessary was to get as flat a steam consumption curve on the high-pressure turbine as was possible. Consequently, it was suggested to the various turbine manufacturers that this might be obtained by the use of several steam admission valves on the high-pressure machine instead of the single valve such as that used on 1200-lb. plants already in operation. After considerable discussion, this was agreed upon and turbines having four or five valves were designed. It appears that these machines are now being supplied to all stations of this class now being built. Contrary to what might be expected, it was found that the first cost of the 1200-lb. turbine generator, as now constructed, is little more per kw. capacity than the 400-lb. unit and is cheaper than the 550-lb. compound reheat units.

High-pressure station design requires an exceedingly

careful study of the arrangement and proportion of the heating surface of the steam generating units in order to obtain the most economical assembly of water walls, boiler, superheater, reheater, economizer and air heater. This study invariably leads toward a reduction of high cost steam parts as, with higher pressure, multiple extraction plants with an increase in temperature of steam and exhaust gases, less of the very high cost boiler surface and more of the less expensive economizer surface is required. Also, with higher feedwater temperature, less economizer surface and more air heater surface may be used; air heater surface being the cheapest surface of all. The proportion of these surfaces affects the first cost of the station materially.

With the use of water walls to reduce furnace heat maintenance, evaporators, pulverized fuel and many other features governing boiler operation, it is now possible to operate a boiler almost continuously, the outages

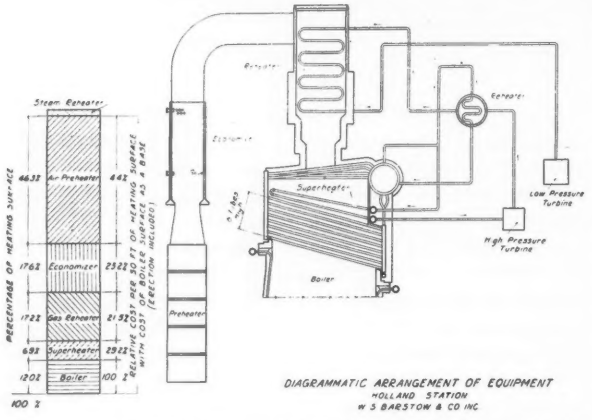


FIG. 3. RELATIVE UNIT COSTS OF VARIOUS TYPES OF HEATING SURFACE

for cleaning and maintenance covering only a very small portion of the time. This being the case, with a thoroughly interconnected system, it has been found much more economically sound to carry the load dropped during these boiler outages, on other plants of the system, or to force the remaining boilers of the plant to a point above normal operation, even at a slightly increased fuel cost, rather than pay fixed charges on the investment necessary for an added spare boiler. In other words, in a thoroughly interconnected system, a high-pressure boiler with its large investment cost should take its place beside the turbine, when considered in relation to the economic installation of spare capacity. Consequently, in these studies for the Holland station, no spare boiler is considered for any of the pressures studied. In view of these things, it seemed best to consider two boiler units per turbine, at least for the first machine, and comparisons were made on that basis.

In practically all plants previously designed where reheat has been used, it has been the custom to build special reheat boilers which generated less steam than the other boilers in the plant and which used most of the heat liberated in its furnace for reheating the steam not only from that boiler itself but from other boilers on the system. With a plant designed for unit operation, especially when only the first unit was being installed, this method had obvious objections. If a plant could be designed with all steam generators built on the same general plan, it would facilitate ease of operation and would cripple the plant considerably less if any one boiler went out of service. It would also simplify regulation of the plant, and this was an object which was highly desirable.

Many Different Arrangements Considered

The first arrangement considered for the Holland Station, consisted of a bent tube boiler with an interdeck convection superheater combined with one of the radiant type and a reheater consisting of radiant type apparatus located in the side walls of the setting. This arrangement of equipment was not entirely satisfactory and the following various modifications were then considered with both bent tube and straight tube boilers: (1) Radiant type reheaters in the bridge wall of the furnace and combined convection and radiant type superheater; (2) Radiant type superheaters in the furnace side walls and convection interdeck reheaters; (3) Radiant type superheaters in the side walls and radiant type reheaters in the bridge wall; (4) combined steam reheater and radiant type reheater together with a convection type superheater; (5) radiant type superheater in the furnace side walls with a reheater built into the last pass of the boiler; (6) the same arrangement with a second-stage convection reheater; (7) a radiant type superheater in connection with these various combinations of an auxiliary steam reheater placed in series with a convection reheater; (8) the use of separate reheat boiler, and (9) the use of two separate steam reheaters in series, using saturated steam at full boiler pressure and two-stage reheating.

After carefully considering all of these possible arrangements and equipment and balancing cost and economy, it appeared that the best arrangement was that shown in Fig. 3. This arrangement provides for water walls, a convection type superheater, a first-stage steam reheater and a second-stage gas reheater, economizer and air preheater and all boilers to be built on similar lines.

Steam from the boiler flows to the convection superheater and thence to the high-pressure sections of the turbine which exhausts to the steam reheater operated in series with the flue gas reheater and is returned to the low-pressure section of the turbine. Saturated steam from the boiler is used in steam reheater for supplying the heat and constant reheat temperature is obtained by thermostatic regulation of the steam to the steam reheater, the proportions of the two reheaters being so arranged that at full load the steam reheater is nearly cut out, the flue gas reheater furnishing all the heat required.

Heating Surface Cost Comparison Aids in Boiler Selection

Percentage of the total heating surface provided by each piece of apparatus, together with the relative cost per sq. ft. of heating surface for each, using the cost of boiler surface as a basis, is also shown in Fig. 3 Comparisons between bent tube and straight tube boilers favored the latter type in this case for the following reasons: (a) in the high-pressure boiler, the greatest expense attaches to the drums, and the straight tube boiler with one drum had an advantage in cost; (b) the straight tube boiler allowed a more satisfactory arrange-

ment for the gas reheater, as it was difficult to place it between the first and second passes of the bent tube boiler; (c) the straight tube boiler allowed almost all of the high-priced boiler surface to be located in the high temperature zone with the reheater immediately above and makes the most economical general arrangement of all of the heating surface; (d) the straight tube boiler construction lends itself more economically to space consideration when considering the method of pulverized fuel firing that it was desired to use.

Arrangement of auxiliary equipment which was decided upon and the cycle diagram involved, are shown in Fig. 4. The condensate, after leaving the condenser, is first pumped to a surge tank with a float valve control which may divert the condensate to an evaporated water storage tank, if necessary. The drip from the evaporator condenser is also returned to this surge tank. This condensate, or feedwater, is delivered to the boiler through the agency of three separate pumps acting in series.

Operating against a head of 70 lb., the first pump delivers water to the deaerating heater at 273 deg. F., full load, after forcing successively through the first stage heater, which takes steam from the 14th stage of the low-pressure turbine; the small vent condenser which is supplied with heat by the vent from the deaerating heater and the evaporator condenser, which condenses the steam coming from the evaporator and the turbine gland seals, the evaporator receiving its steam from the sixth stage of the turbine. The second steam pump, which operates against 600 lb. maximum pressure, forces the water through the third stage heater takes the steam from the sixth turbine stage in parallel with the evaporator and the fourth stage heater which is supplied from the crossover header, receiving exhaust from the high-pressure turbine. The third steam pump, working against a maximum pressure of 1600 lb., takes the water which has now reached a temperature of 430 deg. F. at full load and discharges it to the boiler through the economizer. The deaerator heater is supplied with steam from the tenth stage of the turbine and is equipped with float control for regulation of water supply at that point.

Fuel Pulverizing and Burning Equipment

Designed primarily to use bituminons coal, the plant is so arranged that part anthracite could be used and with some small changes and additions in milling capacity, a complete anthracite burning plant is possible if this should become advisable due to future developments in this direction or to marked change in coal supply or prices.

Mill drying is being installed with the bin system, the vents from the mill being used for secondary air supply to burners. It was demonstrated that with proper speed control, for variable loads, on the direct-fired system in the present stage of development and a careful selection of the proper sized mills by both systems, there was little, if any, difference in the total investment necessary for either bin or direct firing.

With the bin system, it was possible, without extra cost, to design the plant so that all fuel could be pulverized at night during the off peak period. This reduces labor costs, increases station load factor and lessens station requirements during peak load hours. It really adds about 1000 kw. to the salable peak capacity of the plant and credit can be taken for the investment otherwise required to install this capacity. It also reduces the amount of operating machinery required during the peak load hours and thus simplifies operation at a price of time when it is most desirable.

Further advantage of the bin system is the matter of arrangement as it was decided to make use of the opposed method of firing, whereby burners would be located on two opposite sides of the furnace.

Selection of Fuel and Design of Furnace

Opposed firing permits of better arrangement of burners in respect to the side walls where direct impingement is undesirable and increases the flexibility of operation. It gives greater furnace turbulence, improving combustion and reducing the time required to

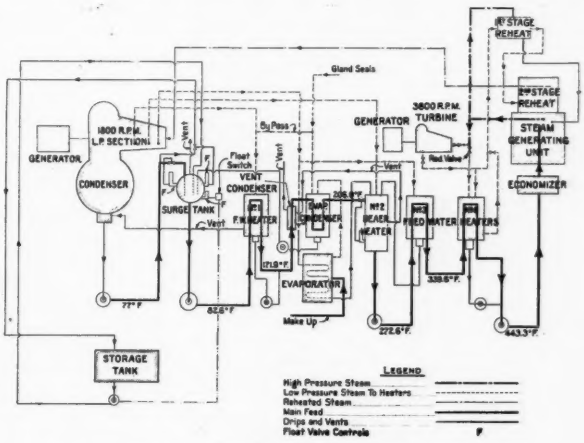


FIG. 4. HEAT CYCLE DIAGRAM OF AUXILIARY EQUIPMENT

complete this combustion, thus probably reducing carbon in the fly ash and danger of slag on the boiler tubes. It also enables anthracite and bituminous coals to be fired separately but thoroughly mixed during combustion.

Designed for a heat liberation of about 18,000 B.t.u. per cu. ft. at 250,000-lb. steam per hr. and having side walls of the fin tube type, each provided with burners consisting of spare tubes set in brick work, the furnace is equipped with a special water screen above a dry ash pit of new design. Its general ash arrangement is so laid out that it can be changed to a slag tap bottom at a later period, if desired, without any major or costly changes.

With four stages of steam extraction as employed, the condenser with its piping and auxiliaries is considerably reduced in size. For the Holland station, which is designed for high vacuum and good load factor there will be only a little over 0.7 sq. ft. of condensing surface per kw. capacity of the low-pressure section of the turbine which corresponds to less than 0.6 sq. ft. per kw. of total turbine capacity. The condenser will be of the single-pass type with horizontally divided water boxes, and arranged for reversing the circulating water flow. The tubes will be expanded into both inlet and discharge tube sheets. and expansion and contraction will be compensated for by means of expansion joints adja-

cent to the tube sheets. The condenser will be arranged for bolting directly to the exhaust flange of the turbine.

Motor Drive Adopted for Auxiliaries

Four high tension and two low tension 33,000-v. circuits tying all other system generating plants and interconnections together, will be fed directly by the Holland plant. If all of these lines were out of service at the same time, the output of the station would not be needed and if any one of them were in service, it would provide ample power for maintaining the auxiliary service. In other words, the station auxiliary system will be supplemented by all of the other stations in operation on the system and also by interconnection with other systems. Therefore, no steam-driven auxiliary will be provided except an emergency boiler feed pump.

Equipment Specified for Holland Station

- 2 Babcock & Wilcox wrought steel sectional cross drum boilers, each having an effective heating surface of 7928 sq. ft., 1400 lb. working pressure, equipped with Babcock & Wilcox superheaters, working pressure 1400 lb. designed to superheat steam to a total temperature of 750 deg. F.
- 2 B. & W. convection type reheaters each having a heating surface of 11,450 sq. ft. and built for a working pressure of 425 lb.
- 2 B. & W. steam heated type reheaters, each containing 1508 sq. ft. of heating surface, and built for 425 lb. on the low pressure side and 1400 lb. on the high pressure side.
- 2 Foster Economizer units, each to contain 11,880 sq. ft. of external heating surface.
- 2 Foster Plate type sectional air heater units, each air heater will contain 32,450 sq. ft.
- 2 Sturtevant steel plate induced draft fans, Type IV—ID, size 1006½.
- 2 Sturtevant special 115 Turbovane Design 5, forced draft fans equipped with vane control.
- 1 No. 70 Lehigh air separation type gear driven pulverizer mill, including one exhaust fan and one cyclone dust collector. Capacity 18 t. of coal per hour.
- 1 Raymond air-swept 6-roll supermill equipped with two pneumatic feed controls, one No. 14 exhauster, one 9-ft. collector, one booster vent fan, capacity 19 t. of coal per hour.
- 12 24-in. Corch adjustable "C" burners.
- 2 Sets of water screens as described. Boiler No. 1 bottom screen plain tubes; front, rear, and side are fin tubes. Boiler No. 2, front, rear and bottom, plain tubes, side, fin tubes.
- 2 Ingersoll-Rand No. 5 RST Type, six stage, horizontally split cast iron casing, centrifugal primary boiler feed pumps, 1185 g.p.m., 275 deg. F., 1750 r.p.m.
- 2 Ingersoll-Rand No. 5 HT type, five stage, horizontally split steel casing centrifugal secondary boiler feed pumps, 1316 g.p.m., 440 deg. F., 3450 r.p.m.
- 1 General Electric cross compound turbine generator unit having a total capacity of 55,000 kw. consisting of a 11,800 kw. at 85 per cent p.f., 13,880 kv-a., 13,200-v., high pressure element operating at 3600 r.p.m., and a 43,200-kw., 85 per cent p.f., 50,820 kv-a., 13,200-v. low pressure element operating at 1800 r.p.m. with direct connected exciter of sufficient capacity to excite both generators.
- 1 250-kw. General Electric motor-generator set consisting of a KTP 565-6 400-hp., 1200-r.p.m., 2300-v., 3-phase, 60-cycle, motor braced for full voltage starting, direct connected to an MPC-6-250-kw., 1200-r.p.m., 250-v. shunt-wound d.c. generator.
- 2 General Electric generator surface air coolers, total surface for high-pressure generator 5850 sq. ft., total surface for low-pressure generator 15,600 sq. ft.
- 1 Ingersoll-Rand single-pass surface condenser 31,600 sq. ft. tube surface.
- 1 28-in. D. Foster Wheeler 2-pass, low-pressure closed feedwater heater containing 1576 sq. ft. of heating surface.
- 1 26-in. D. Foster Wheeler 2-pass closed, low-pressure heater or condenser containing 1250 sq. ft. heating surface.
- 1 28-in. D. Foster Wheeler high-pressure feedwater heater of vertical "U" bend type, 2-pass design containing 1486 sq. ft. of heating surface.
- 1 Wheeler combination high-pressure feedwater heater and desuperheater of vertical "U" bend type, containing 1836 sq. ft. of effective heating surface.
- 1 Wheeler single effect horizontal shell submerged coil evaporator, containing 352 sq. ft. of heating surface.
- 1 Elliott 450,000 lb. per hr. Type "J" deaerating heater with 75,000 lb. storage capacity.

Circuits and Equipment Centrally Controlled

Centralized station control, in which the chief operating engineer is so located that he not only centrally controls the turbine, boiler and their auxiliaries, but also ingoing and outgoing circuits, was decided upon. Separation of the turbine room and boiler room by the usual wall will be omitted in order to allow the operator a greater range of vision. While the control equipment will not be made fully automatic at first, provision will be made so that it can be easily changed over, later.

Switchboards for the centralized control are to be placed in the high-pressure turbine bay, located in the station, where a clear vision of the turbine and boiler room equipment is obtained with the least obstruction. The electrical equipment including outgoing feeders, generating apparatus and main feed circuits for the station service power, as well as for motor and electrical apparatus vitally necessary for the operation of the boilers and turbine, are controlled from this point. The space and centralized control requirements do not permit the use of conventional type of power house control switchboard with its usual arrangement of control switches, indicating apparatus and protecting relaying equipment. In order to compress the necessary control into the space allotted, it was decided to install a semi-supervisory type of control. This system will differ from cable supervisory in that no telephone relay will be interposed between control keys and auxiliary relays. In effect, it will be miniature, remote control.

Protective relay equipment, serving the transmission lines, generating equipment and main station service feed circuit, will be concentrated on panels at a convenient point to the entrance of the conduit duct-run from the outdoor substation, thus, minimizing the conduit space required under turbine room operating floor. Upon this board are to be placed control buttons for use in operating the electrical equipment in emergencies and the auxiliary relay equipment necessary to change the control impulses from the keys at 50-v. direct current to the control circuits at 250-v. direct current.

As the station grows, it may be advisable to build the usual separate switchboard room and use special operating men for this purpose and this has been provided for in the design. Comparison of investment charges show that the installation proposed will cost no more than the regulation layout when the cost of changing to the above future arrangement is considered.

Electrical Features

Generator bus structures and the 114 and 33-kv. substations will be of the outdoor steel angle frame type. The station service cell structures are to be located on two floors above the high-pressure bay approximately midway between boiler room and turbine room.

Station service power is to be obtained from two sources: The main station service bank is a three-winding type of equipment with 13,200-v., 2300-v., and 220-v. windings. This bank is tapped directly off of the general bus through disconnecting switches. The alternate source of station service power for use during times of shutdown and with sufficient capacity for starting up the plant, is to be obtained from a third winding in a grounding bank for the 33-kv. system. Synchronizing on the 114-kv. circuits is to be accomplished by

means of condenser bushings in the oil circuit breakers with synchronizing networks, thus saving the cost of potential transformers, since no metering is done at this voltage.

General Equipment Conveniently Arranged

Design and location of the pulverizing room, which is so arranged that it might readily be called a unit bin system, is noteworthy in its small space requirements and convenience for operation in connection with the rest of the plant. The general arrangement of equipment is shown in Figs. 5 and 6. The high-pressure turbine is placed on the main turbine room floor under the balcony and its weight is supported entirely by the floor structure, thus leaving the entire space below the turbine for other purposes. On the floor above this machine, switchboard galleries have been installed and a small auxiliary crane for maintenance work is placed above the high-pressure turbine. The centralized control board will be placed practically on the line of columns between this turbine and the boilers.

Should trouble occur to the high-pressure turbine, making it desirable to run the plant as a low-pressure plant while maintenance was being made, the fourth stage heater can be used as a desuperheater. This being a condition which it is hoped will occur but seldom, the changing over of the heater from its usual function to a desuperheater has not been arranged to be automatic but this can be done should it be desired. Air-tight doors which are motor operated and provided with remote control, will be placed directly below the gas reheaters so that cold air may be thrown into the setting at this point, thus preventing the overheating of the reheaters should the high-pressure turbine trip out.

Location and design of the pulverizing room are of particular interest because of the small building space required and the convenience for operation. The pulverizing room is so arranged that it might readily be called a unit bin system.

This presentation is unique in its thoroughness of analysis and in its implied prediction of results. Interest will center around the completion of the project to see how near the able designers accomplished their design. Construction work on the station is progressing rapidly and it is expected that the station will go into operation about October, 1929.

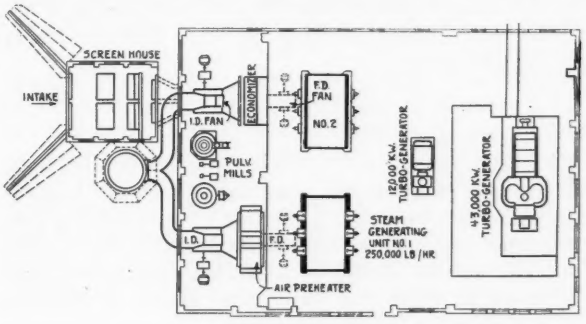


FIG. 6. PLAN OF STATION SHOWING RELATION OF THE MACHINE EQUIPMENT AND THE CENTRALIZED CONTROL BOARD WHICH IS LOCATED BETWEEN MAIN TURBINE AND BOILERS

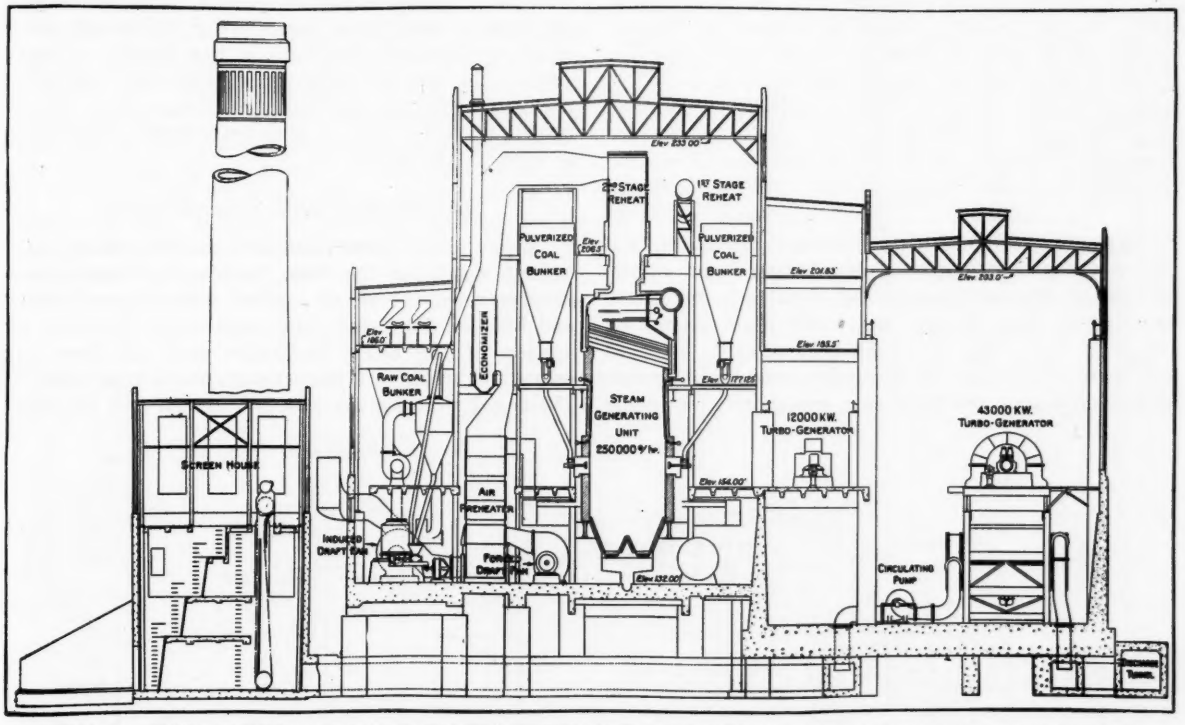


FIG. 5. CROSS SECTION OF PLANT SHOWS ATTENDANCE CONVENIENCE AND ECONOMICAL USE OF SPACE

Riverside Power Co., Davenport, Iowa, operated by the United Light & Power Co., has approved plans for the construction of an addition to its steam power plant in the Bettendorf district with the installation of a 30,000-hp. turbine generator and auxiliaries to cost about $850,000. A. S. Bisbee is superintendent of construction.

How Good Water Is Secured for a Blast Furnace Plant

Interesting Water Treating Plant Supplies Water for Boiler Feeding, Cooling in the Processes and Other Purposes at Massillon

By T. J. Ess

IN THE CONSTRUCTION of the power and blast furnace plants at the Massillon Works of the Central Alloy Steel Corp., the question of water supply and treatment presented an interesting problem. The source of water supply consists of four 24-in. wells, about 120 ft. deep, in which the water rises almost to the top, located near the Tuscarawus River.

TABLE I. TYPICAL ANALYSES OF WATER AT THE CORPORATION'S PUMPING STATIONS

	No. 1 Pump-house	No. 2 Pump-house	No. 3 Pump-house	No. 4 Pump-house
$CaCO_3$	10.40	13.74	13.53	12.48
$MgCO_3$	3.17	2.07	....	2.08
$CaSO_4$	7.65	23.80	14.00	1.12
$MgSO_4$	.21	.87	....	3.57
$MgCl_2$	1.26	5.14	6.47	....
NaCl	9.01	17.04	16.34	6.53
Silica	.58	.74	.64	.58
Iron and aluminum oxides	.19	.42	.19	.17
Hardness, gr. per gal., as $CaCO_3$	21.41	39.92	27.29	18.74

Three Worthington service pumps (10-in. centrifugal 2-stage, 3500 g.p.m. against 210-ft. head, driven by General Electric motors) are installed to pump the water to the blast furnace and power plant located on a near-by hill. This water has a practically constant temperature of 55 deg. F. Normally, two pumps operate continuously with the third as a space unit, producing an average of 285,000,000 gal. per mo. The bulk of the water thus furnished is used by the blast furnace and coke plant, the only raw water used in the power plant being in the ash hopper sprays.

This well water is extremely hard, running as high as 28 grains of encrusting solids per gallon. Typical analyses of the water obtained from the various pumping stations of the corporation are given in Table I. In spite of the difference between the various stations, the water from any one station remains fairly constant in analysis. Experience had shown that solids were thrown out even in cold water lines. After a thorough study of all surrounding conditions, it was decided to install surface condensers and a spray pond, and recirculate the condensing and cooling water, thus making it practical to treat the water so as to prevent the precipitation of solids in the system.

Services Requiring Treated Water

Water to be softened included the condensing water, cooling water for the blast furnace, hot blast stoves, generator air cooler, oil coolers, turbo-blower casings and light oil stills, and boiler feedwater. With the exception of the boiler feedwater, none of these uses heated the water to a temperature above approximately 150 deg. F. It was accordingly decided that the water

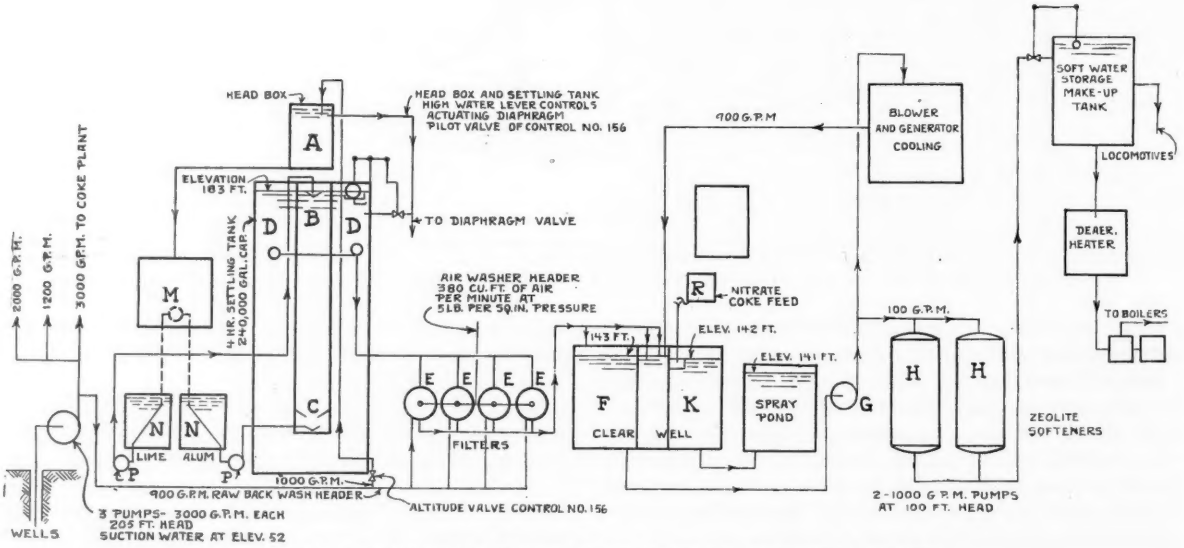

HEAD BOX
HEAD BOX AND SETTLING TANK HIGH WATER LEVER CONTROLS ACTUATING DIAPHRAGM PILOT VALVE OF CONTROL NO. 156
900 G.P.M.
BLOWER AND GENERATOR COOLING
SOFT WATER STORAGE MAKE-UP TANK
LOCOMOTIVES
ELEVATION 183 FT.
TO DIAPHRAGM VALVE
DEAER. HEATER
TO BOILERS
2000 G.P.M.
1200 G.P.M.
3000 G.P.M. TO COKE PLANT
4 HR. SETTLING TANK 240,000 GAL. CAP.
AIR WASHER HEADER 380 CU. FT. OF AIR PER MINUTE AT 5 LB. PER SQ. IN. PRESSURE
R NITRATE COKE FEED
100 G.P.M.
143 FT.
ELEV. 142 FT.
ELEV. 141 FT.
FILTERS
CLEAR WELL
SPRAY POND
ZEOLITE SOFTENERS
LIME
ALUM
1000 G.P.M.
900 G.P.M. RAW BACK WASH HEADER
ALTITUDE VALVE CONTROL NO. 156
2-1000 G.P.M. PUMPS AT 100 FT. HEAD
3 PUMPS- 3000 G.P.M. EACH 205 FT. HEAD SUCTION WATER AT ELEV. 52
WELLS

FIG. 1. DIAGRAM OF WATER FLOW THROUGH TREATING PLANT

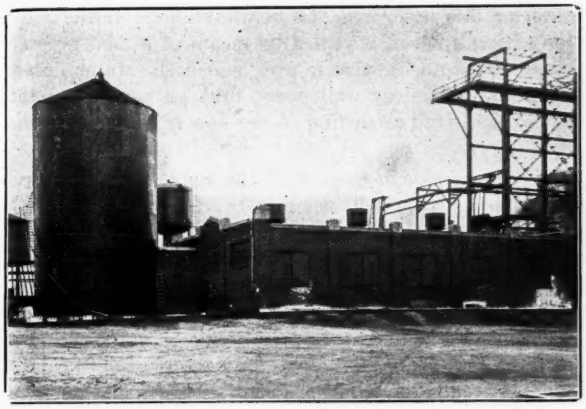


FIG. 2. SOFTENING PLANT BUILDING AND SEDIMENTATION TANK

should be given a treatment with lime to eliminate the carbonates, aided by alum as a coagulant. After settling and filtering, the cooling water was to receive an acid treatment, while the boiler feedwater passed through zeolite softeners. This acid treatment reduces the alkalinity and reacts with the bicarbonates remaining after the lime and alum treatment to form sulphates, reducing the temporary hardness so low that even after moderate heating no precipitate is formed.

Figure 1 shows a schematic diagram of the water flow, for a plant designed to accomplish this, furnished by the Permutit Co. of New York. The raw water enters a head box (A) located in the top of the sedimentation tank, and is controlled by an automatic Schade valve. The water then passes through an adjustable orifice in the bottom of the head box, into a mixing cone (B), where the lime solution is added, and then settles through the down-take in the center of the tank. At the bottom of the down-take is a second mixing cone (C), where the alum solution is added. From here the water rises in the tank around the outside of the down-take. At the rated capacity of the plant, about 4 hr. are required for the water to travel through the sedimentation tank, of which about 25 min. elapse between the lime feed and the alum feed. The sedimentation tank is 39 ft. high by 33 ft. in diameter, holding about 250,000 gal. The cylindrical down-take is 10 ft. in diameter.

At the top of the tank, a perforated pipe ring (DD) draws off the water, which then flows through any of four horizontal filters (E), 8 ft. in diameter by 14 ft. long, and into a clear well (F). Either of two 1000-gal. pumps (G) at 100 ft. head takes water from this clear well for the zeolite softeners (H) and for power house cooling. The zeolite completes the softening of the water intended for boiler feed use, and this water then passes into a 20,000 gal. storage tank, located in the yard, supplying boiler feed make-up as well as water for locomotives. The water used for power house cooling is returned to a second clear well (K), where it receives an acid treatment with a solution of niter cake.

Chemicals Received Direct from Railroad Cars

Figure 2 shows the softening plant building and sedimentation tank. The four sliding doors on the side of the building open directly into the chemical bins, making it possible to receive chemical directly from railroad cars. As can be seen in Fig. 3, the mixing tanks inside of the building are so located as to be near to their respective storage bins, so that a minimum amount of effort is required in charging the tanks. Figure 4 shows the battery of four filters for clarifying the lime and alum treated water. Figure 5 shows the zeolite softeners.

In the bottom of the head box (A, Fig. 1) is a second orifice, very small, the flow of water through which varies exactly as the flow through the large orifice, due

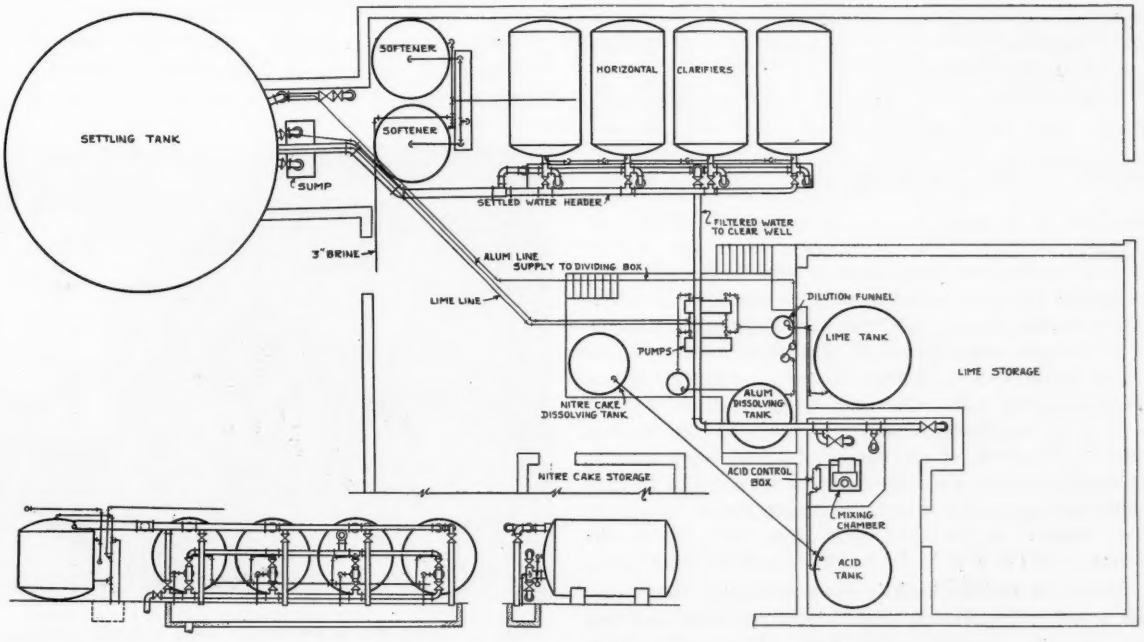


FIG. 3. GENERAL ARRANGEMENT OF SOFTENING PLANT BUILDING

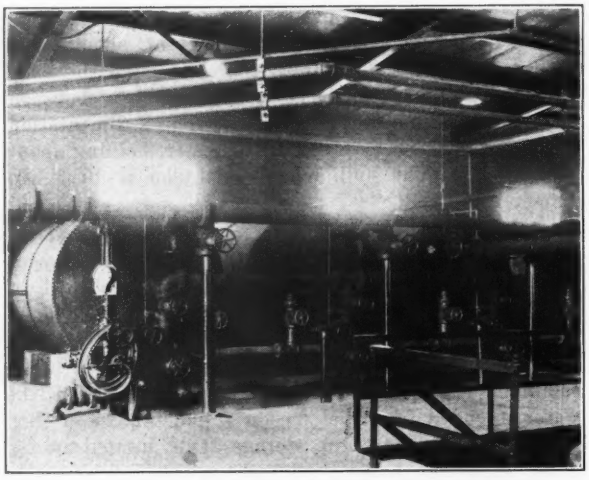


FIG. 4. BATTERY OF PRESSURE FILTERS

to the same head of water acting on both orifices. The amount of water passing through the small orifice is therefore at all times proportional to the amount passing through the large orifice, in the ratio of their respective areas. The water from this small orifice flows down to a tipping meter (M, Fig. 1), consisting of a two-compartment bucket mounted over a container. Each compartment alternately receives the fractional stream from the small orifice, and after it fills, it tips over, and by pawl, ratchet and worm gears, it slowly rotates a drum.

On this drum are wound small bronze cables attached to the upper open end of swing-joint lift pipes placed inside the lime and alum solution tanks (N). The rotation of the drum pays out the cables, thus lowering the lift pipes and permitting the solutions to flow into the suction boxes of the chemical pumps. The speed of operation of the tipping meter, with the resultant flow of chemical solutions, depends entirely on the flow of water from the small orifice in the head box, so that the rate of chemical feed is proportional to the flow of water into the sedimentation tank.

Suction boxes of the chemical pumps are fitted with water pipes and float valves to dilute the chemical streams and to provide constant volumes of solution in spite of the varying discharges from the chemical tanks.

Arrangement of Tanks

Centrifugal lime and alum pumps (PP) lift their respective solutions into the sedimentation tank, where they are mixed with the water undergoing treatment. These pumps, both driven by the same motor, are installed in duplicate. Figure 6 is a photograph of the chemical pump pit. The lime pump suction box can be seen in the background, with part of the tipping meter visible back of the hand-rail. The large tank in the background is the alum solution tank. The tank in the foreground is the niter-cake mixing tank. The niter-cake solution is conveyed from this tank up to the storage tank (R, Fig. 1) by means of a steam jet syphon.

From the storage tank it flows through a float operated needle valve into a small lead lined head box and out through a flexible rubber hose. The height of the outlet of this hose, with the resultant head of the solution acting upon it, is varied by means of a float according to the head on a weir over which the water entering the second clear well flows, thus proportioning the rate of acid feed according to the flow of water over the weir.

From the second clear well, the water flows by gravity to the spray pond, which is 167 ft. by 375 ft., with a capacity of approximately 2,340,000 gal. The spray pond water is circulated at the rate of 26,100 g.p.m., causing the entire pond to be turned over once every 90 min. The usual range of cooling in the pond is 18 to 20 deg. F.

In the bottom of the sedimentation tank is a sludge removal system of manifolds and laterals. This is operated once every 24 hr., which is sufficient to eliminate the sediment formed in the tank so as to ensure clear water at all times.

Gages showing the pressure loss through the filter bed are installed on the filters. When this loss becomes excessive, it indicates that the filter requires back-washing. This is done once every 24 hr., using water at a rate of flow of 900 g.p.m., together with compressed air agitation, which keeps the pressure loss within reasonable limits.

Proportioning of Chemicals

Each unit of the zeolite softener is equipped with a water meter, totalizing the flow through its particular unit. When a meter indicates that 60,000 gal. have passed through that unit, it is regenerated with a solution of common salt. Salt consumption in the zeolite softeners runs about 5 lb. per 1000 gal. so treated. The zeolite softener is rated at 200 g.p.m.

The rated capacity of the continuous lime-alum treating system is 1000 g.p.m., and this rate of operation is reached in peaks. Average operation shows a monthly output of 26,000,000 gal. of which 6,000,000 gal. was also treated with zeolite. Average chemical consumption is approximately as follows:

Lime	1.65	lb. per 1000 gal.
Alum	0.34	" " " "
Niter Cake	0.81	" " " "

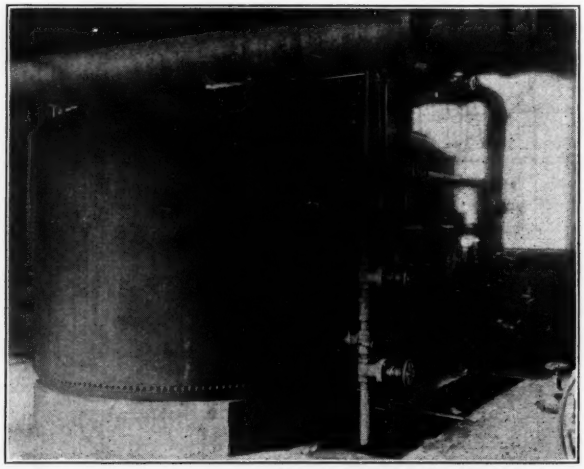


FIG. 5. ZEOLITE SOFTENERS AND THEIR CONTROL VALVES

Chemicals are mixed in the solution tanks in batches as follows:

Lime	700 lb.
Alum	120 "
Niter cake	300 "
Salt	1400 "

Hydrated lime is used, with the content of available calcium oxide as high as possible, usually running about 98 per cent. Efforts are made to obtain alum of a good grade. This runs 57 to 58 per cent aluminum sulphate, 0.5 per cent insoluble matter, and 0.1 per cent free acid. Impure alum is likely to cause trouble by forming a slimy sludge. Niter cake runs about 37 per cent sulphuric acid. Ordinary commercial salt is used. The 1400 lb. mixed as a batch is good for five regenerations of the zeolite softener. A saturated solution, running about 22½ deg. Baumé, is maintained in the brine vat.

TABLE II. TYPICAL ANALYSES OF WATER THROUGH THE VARIOUS STAGES OF THE SOFTENING PLANT

		Parts per million			
		Raw water	Lime & alum treated water	Lime, alum & niter cake treated water	Lime, alum & zeolite treated water
Total hardness	as CaCO3	350	164	164	0
Calcium hardness	as CaCO3	225	100	100	0
Magnesium hardness	as CaCO3	125	64	64	0
Alkalinity, MO	as CaCO3	241	45	15	45
Basicity-alkalinity, Ph	as CaCO3	0	6	0	6
Free carbon dioxide	as CO2	44	0	1	..
Chlorides	as Cl	85	86	86	86
Sulphates	as SO3	113	140	164	140
Iron	as Fe	.4	0	0	0

One man on each of three 8-hr. turns carries on the entire operation of the plant. Daily titrations are made on samples of treated water taken at regular intervals through the day. These titrations are not performed by the plant operator, so that a check is maintained on the operator's performance.

Analyses of Water in Various Stages

Table II gives typical analyses of the water through the various stages of the softening plant. The lime, alum, and niter cake treated water shows a hardness of approximately 10 grains per gal., but as all of this is "permanent," or sulphate hardness, no precipitation takes place in any part of the cooling system. The spray pond has operated continuously for over 2 yr. without draining or cleaning. A small amount of wastage from the pond keeps the concentration down. Total make-up to the pond runs about 1.65 per cent of the water circulated, of which about 0.7 per cent is blow-down and 0.95 per cent evaporation and windage.

After over 21 months of operation, the surface condensers were opened for washing, at which time no scale or sludge deposit whatever was found.

Zeolite softened water deposits no scale in the boilers but leaves the surfaces entirely clean. The boilers do not prime or foam, though operated at peak ratings as high as 326 per cent. Concentrations in the boilers are held rather low, the boilers being blown every 6 hr. Blow-down thus averages about 4.3 per cent. Typical concentrations obtained are as follows:

Boiler No. 1...192 grains per gal....3300 p.p.m.
" " 2...153 " " " " ...2620 "
" " 3...132 " " " " ...2265 "
" " 4...137 " " " " ...2350 "
" " 5...172 " " " " ...2950 "
" " 6...130 " " " " ...2225 "

Variation in these figures is due to the fact that one boiler is blown every hour, whereas the samples are all taken at one time, regardless of the times of blow-down. A maximum of 300 grains per gal. is set as the upper limit for good operating conditions.

In the course of passage through the softening plant, the water picks up entrained oxygen to the amount of 5 c.c. per liter. If this quantity of oxygen were allowed to enter the boilers, corrosion and pitting would result. Accordingly, the feedwater is passed through a deaerating heater, which lowers the oxygen content to less than

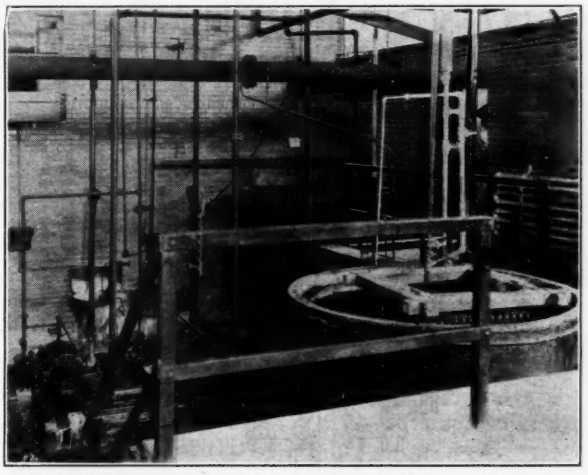


FIG. 6. CHEMICAL PUMPS AND MIXING TANKS

0.05 c.c. per liter, which seems effectively to eliminate any corrosion or pitting.

Though the treating process and equipment may sound somewhat complex, it is really simple in construction and operation. Operating costs are below the average, all guarantees have been met and performance is very reliable, having operated for more than 2 yr. without any serious delay or trouble.

Viscosity of oils varies inversely with the temperature; that is, the higher the temperature, the more fluid will be the average lubricant. Under controllable conditions, this is an asset, for it may permit one lubricant being used to serve a number of points with varying external temperature, provided the size of the bearing elements and the pressures exerted are taken into account when the lubricant is originally selected. Viscosity is, therefore, an indication of the relative fluidity of an oil at the temperature specified. It is that inherent property by virtue of which the flow of liquids is retarded and is possessed by all oils in varying degrees and is in effect a measure of the resistance offered to the particles or molecules of the liquid in sliding past each other.

When pouring concrete for core walls of dams, unusual care must be taken to prevent having spongy spots which would later allow leakage.

Keep the Turbine Governor in Good Condition

SPEED GOVERNOR, OVERSPEED GOVERNOR AND BYPASS VALVE MECHANISM ARE THE HEART OF THE TURBINE. THEY SHOULD BE FAMILIAR TO THE OPERATOR.

SPEED REGULATION of the modern turbine is, except in rare cases where load and steam conditions remain constant, under the control of a governor system. In the majority of cases, the function of the

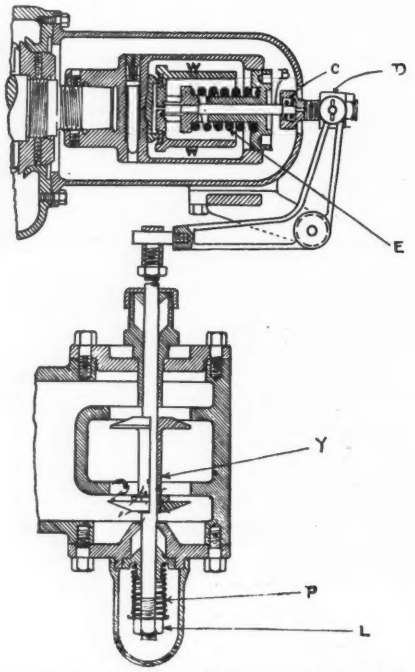


FIG. 1. A DIRECTLY OPERATED CENTRIFUGAL GOVERNOR OF THE THROTTLING TYPE

governor is to maintain a constant speed regardless of load demands or steam pressure variations, although there are special cases, as in centrifugal blower or pump operation, where the speed is regulated to maintain a nearly constant discharge pressure.

Governing systems consist of three main parts: the controlling device proper, which is sensitive to speed or pressure changes; the valve which actually controls the turbine speed by regulating the steam flow; and the connecting mechanism between the two. It is customary to classify governors in three ways, according to the actuating force, as centrifugal, centrifugal and inertia, pneumatic or hydraulic; according to the method of valve control as direct or relay and according to the method of steam control as throttling, multiple valve or intermittent.

Practically all modern governors are of the centrifugal type depending for action upon the centrifugal force exerted by rapidly revolving pivoted weights. The spring type has the advantage of being powerful with comparatively little inertia effect and as such is now favored for turbine service. For special conditions such as centrifugal blowers and sometimes centrifugal pumps the discharge pressure of the air or water, which is a function of the speed, is used to actuate the steam valve of the turbine, a rise in pressure slowing up the turbine and a drop in pressure causing a speed rise, similar in action to the pump governor so commonly used in boiler feed systems. In other systems, this characteristic of blower or pump is used as the governor, the shaft operating a small pump which varies the oil or air supply to the operating cylinder in accordance with the speed.

LARGE MACHINES ALWAYS USE THE RELAY SYSTEM

In the simplest systems, the centrifugal governor is connected directly to the steam valve. Other designs on larger units operate through a lever or series of levers as in Fig. 1, while in still others the actual movement of the valve is accomplished by a separately operated mechanism, the governor simply controlling pick up and release latches as in a Corliss valve gear.

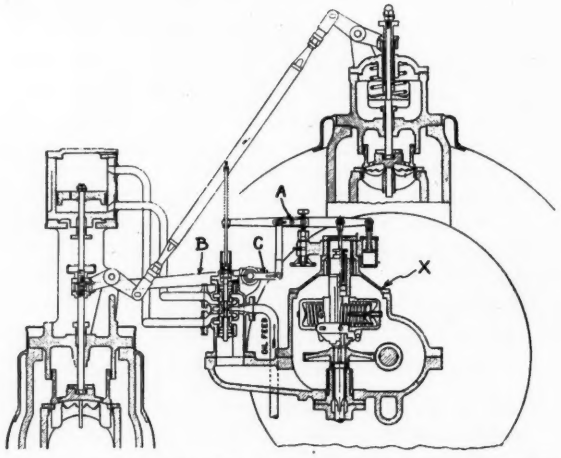


FIG. 2. BYPASS VALVES ARE USUALLY OPERATED BY THE GOVERNOR. THIS IS A CENTRIFUGAL OIL PRESSURE RELAY TYPE THROTTLING GOVERNOR

Direct-acting governors of the above type are used only on the smaller machines, however, as it is not practical to design a governor strong enough to control a large valve directly. For this reason, large machines are fitted with relay governors, in which the governor proper operates a pilot valve admitting steam or oil under pressure to a separate cylinder which in turn, either directly or through a series of levers, operates the steam valves.

One type of relay governor is shown in Fig. 2, a somewhat diagrammatic representation. The governor proper A is of the centrifugal spring type driven by means of a worm gear from the main shaft. It operates a balanced throttle valve by means of the oil cylinder B and pilot valve C. Another type of oil pressure governor is shown in Fig. 3. Oil pressure is maintained by the pump H. The governor proper C is of the spring type as before and it controls directly the oil bypass D to regulate the pressure in the oil line L. As the oil

pressure rises, the valves M are opened and closed in turn.

The first three governors illustrated are of the throttling type, steam being throttled by the steam valve according to the load on the turbine. The governor illustrated in Fig. 3 is of the multiple valve or variable nozzle area type while the governor shown in Fig. 4 is of the intermittent type with steam admitted to the turbine in puffs occurring at regular intervals of such frequency that the pressure variations are negligible. A rocking motion is imparted to the lever and pilot valve by means of the cam A. This is also an oil pressure relay governor.

Overspeed Governor Usually Set to Trip at About 10 Per Cent Above Normal Speed

Closely allied with the speed governor and working in conjunction with it are the emergency trip and bypass valves. Several types of overspeed or emergency

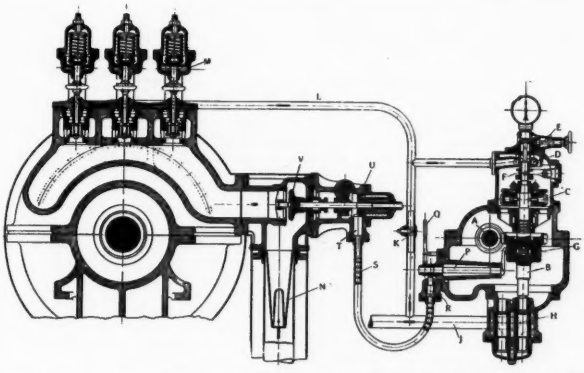


FIG. 3. A SECOND CENTRIFUGAL OIL PRESSURE RELAY TYPE GOVERNOR WITH A MULTIPLE NOZZLE ARRANGEMENT

trip mechanisms are shown in Fig. 5. These governors are ordinarily set to trip about 10 per cent above normal speed and they should be kept in a workable condition. Many engineers make a practice of always stopping the turbine by this means, either by means of the trip lever provided or by holding down the governor if a lever is not provided.

These governors are purely a protective measure against failure or breakage of the speed governor or mechanism. Figure 5A consists of a small pin held in place by a spring. At a certain predetermined speed, this pen is thrown out by centrifugal force, tripping some form of latch which in turn closes the steam valve either directly or through a relay. In Fig. 5B, the same result is accomplished by a ring held in place by a spring while in Fig. 5C, the pivoted lever is used. Action of one of the pin type overspeed governors can be seen in Fig. 3. The pen G trips the small lever releasing oil pressure from the space U so that the valve V is closed by the spring.

Bypass valves sometimes known as secondary and, sometimes on large machines as the tertiary valves are for the purpose of admitting high-pressure steam to the lower stages of the turbine so as to carry overloads. Naturally as the steam expands only through a portion of the turbine, the efficiency is lowered. This disadvantage is more than made up, however, by enabling the turbine to be selected so as to give maximum efficiency at normal load and still be capable of handling overloads.

On small machines, these auxiliary valves are often manually operated but in larger machines they are usually under the control of the governor so connected

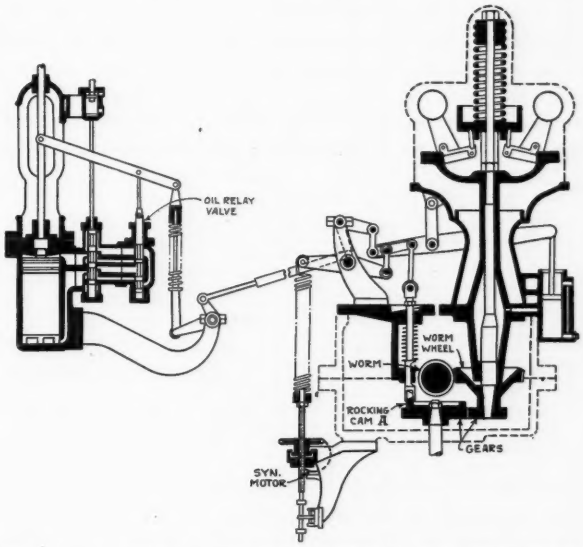


FIG. 4. A THIRD TYPE CENTRIFUGAL OIL PRESSURE RELAY GOVERNOR ADMITTING STEAM TO THE TURBINE INTERMITTENTLY OR IN PUFFS

that they begin to move only after the main valve is fully opened. The valve on top of the turbine in Fig. 2 is a bypass valve of this type.

Other safety devices or governors are also built occasionally to meet special conditions. One such device

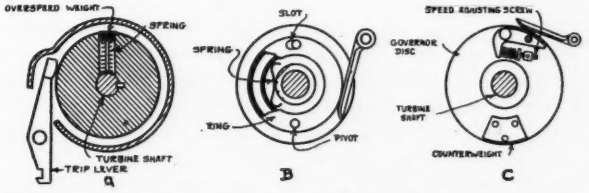


FIG. 5. SEVERAL TYPICAL EMERGENCY TRIP DEVICES FOR OVER SPEED CONTROL

is built for turbine driven pumps. If the pump loses its suction for any reason, the turbine stop is operated and steam flow to the turbine stopped. Another safety device is a vacuum breaker operated by the turbine governor so as to prevent racing the turbine when the load is suddenly reduced.

For water power development, the most desirable streams are those having a fairly constant flow throughout the year. Such streams are comparatively few in number. Streams with a fluctuating flow are not as desirable and utilization of them is more expensive, as sufficient water is not available throughout the year unless costly storage systems are provided. Streams having erratic sudden short flood periods, with intervening periods of little or no water are, as a rule, uneconomical for development.

Interlocking Coal Handling Equipment

By C. O. Von Dannenberg

IN THE usual power station fired by hand or by stokers the general features of the coal handling system are shown in the diagram, Fig. 1. It will be noted that the coal is delivered to a feeder which in turn delivers it to an elevator. The latter may deliver it either to the conveyor and thus to the bunker for immediate use or to the storage pile from which it may

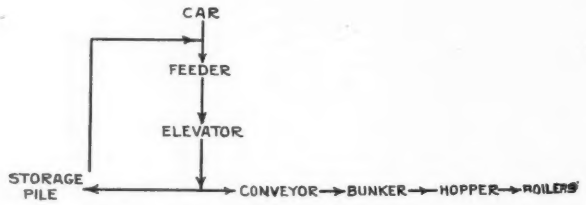


FIG. 1. OPERATING DIAGRAM FOR A COAL HANDLING SYSTEM

be drawn when required. It follows, therefore, that in the sequence of operation, should the conveyor stop, the elevator must also stop and then the feeder to prevent piling up of material at either the delivery point to the conveyor or to the elevator. When the bunker is full and coal is being delivered to the storage pile, any stoppage of the elevator should automatically stop the feeder.

Referring to Fig. 2, there is shown a scheme which accomplishes the desired result by the use of the standard magnet switch which makes it comparatively inexpensive and easy to install. The motors in this instance are of the "across-the-line" starting type eliminating the need of compensators but the general application is a universal one. Taking the equipment in detail, A represents a disconnecting switch of the safety type, B a start-stop push button station and C a standard magnet switch. It should be noted that the current to operate the contactor coil S is obtained from the succeeding motor circuit and can be operated or closed only when the succeeding motor is running. Switch D is a single-pole, double-throw switch mechanically connected to the operating system of the chute which allows the coal from the elevator to be delivered either to the conveyor or to the storage pile as explained.

Details of Operation

For example, should it be desired to deliver coal to the bunker, the chute must be arranged to deliver the coal from the elevators to the bunker; this automatically places switch D in the position F, and makes it impossible to start the elevator motor until the conveyor motor is started since the current for the contactor coil on the elevator motor magnet switch is taken from the conveyor motor circuit; for the same reason, the feeder motor cannot be started until the elevator motor is started, since the current for the contactor coil of the feeder motor is taken from the elevator motor circuit. Any stoppage of current in the conveyor motor circuit will, therefore, open the magnet switch of the elevator motor which will, in turn, stop the feeder motor. Stations X_1, X_2, etc., are on the walkways above the bunker and enable the system to be stopped by the person in charge of filling the bunkers. It is often necessary to stop the operation for a short interval to change the point of delivery in the bunkers. By holding one of these push button stations open, the system can only be started at the desire of the bunker delivery man. This feature is an important one, as the bunker is located usually out of sight and at some distance from the point of delivery of the coal.

When it is desired to deliver coal to the storage pile only, the chute is shifted to the correct position which automatically puts switch D in position G and allows the elevator motor to be started with the conveyor motor shut down. Naturally, the operation of the conveyor,

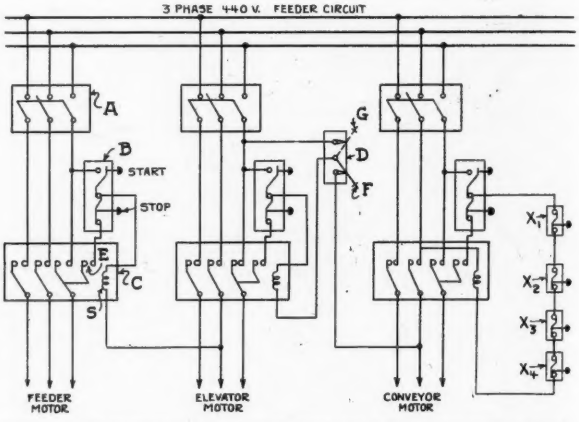


FIG. 2. ELECTRICAL CONNECTIONS FOR MOTORS DRIVING THE SYSTEM, ARRANGED FOR INTERLOCKING

when coal is being delivered to the storage pile, causes no trouble and is simply a useless operation.

The general scheme as outlined can be readily carried out with standard equipment which may be purchased from a number of manufacturers.

Fusain, or mineral charcoal, content of coal from the Pittsburgh vein is not uniformly distributed, according to the Department of Commerce. The fusain content has been found to vary from 1.3 to 4 per cent depending on the locality sampled. There are two varieties of fusain, one hard and one soft. The hard variety is high in ash and contains calcium carbonate, with probably some iron carbonate; the soft variety is low in ash and contains no carbonates. In general, the sulphur content found is low, ranging from 0.13 to 1.13 per cent. Organic sulphur varies from 0.13 to 0.27 per cent. Fusain is easily identified by the microscope; at 70 diameters, it presents a fibrous appearance (woody fibers).

Often, there is a tendency for power plant engineers to strive for high efficiency without balancing the value of it against the resulting increased investment, operating difficulties and higher maintenance. Usually, the designer is too optimistic regarding the useful life of the plant and the capacity factor that it will be operated under.

Comparison of Oil Engine Performances

ANALYSIS OF TESTS ON DIESEL ENGINES DISCLOSES FACT THAT FRICTION LOAD IS CONSTANT OVER THE WHOLE LOAD RANGE AND IN ALL CASES IS PRACTICALLY THE SAME FOR ALL TYPES OF ENGINES. BY OTTO NONNENBRUCH*

RESULTS OF RELIABLE fuel-consumption tests on different types of Diesel engines are analyzed in this paper and conclusions are drawn which lead to a simple method of comparing engine performances and an attempt is made to arrive at standards for fuel economy and rating.

One of the analyses made by the author was of test data of a 4-cycle air-injection engine tested by Romberg, which gave the results plotted in Fig. 1. The m.i.p. (indicated m.e.p.) line shows that the friction losses are constant at all loads and equivalent to 18 lb. per sq. in. mean pressure. The curve m.p. × lb. per hp-hr. represents the product m.e.p. × lb. per br.hp-hr. or m.i.p. × lb. per i.hp-hr.; the two products being alike.

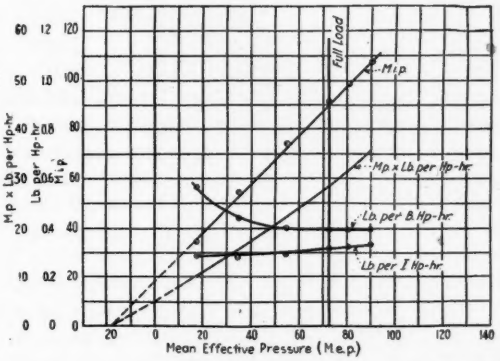


FIG. 1. RESULTS ON KRUPP 4-CYCLE AIR-INJECTION DIESEL ENGINE

Continuing this curve to the left, it cuts the m.i.p. line at the abscissa axis. These characteristics held for all of the tests examined except that the friction load varied for the different engines from 13 lb. to 25 lb. per sq. in.

That the indicated fuel consumption at light loads approaches the same value for all engines, namely, 0.28 lb. per i.hp-hr. is shown in Fig. 2 by the coincidence of the left parts of the m.p. × lb. per hp-hr. curves taken from six tests on different engines. The curves from the 4-cycle engines lie so close together that they are shown as one.

If this indicated consumption of 0.28 lb. per hp-hr. were to continue over the whole load range, the m.p. × lb. per hp-hr. curve would be a straight line as shown dotted in Fig. 2. The actual curves, however, bend away from it as the indicated consumption increases with increasing load. It follows that this curve for any engine may properly be continued to its intersection with the abscissa axis at the left, as a straight line drawn at an angle to the abscissa axis, whose tangent is

[28 (m.p. × lb. per hp-hr.)] ÷ 100 (m.i.p.)

The resulting intersection with the abscissa axis gives the friction mean pressure. The derived friction mean pressure added to the m.e.p. may therefore be considered as giving a very closely correct value of the m.i.p. and dividing the values of the m.p. × lb. per hp-hr. curve by m.i.p., finally gives the indicated fuel consumption over the whole load range.

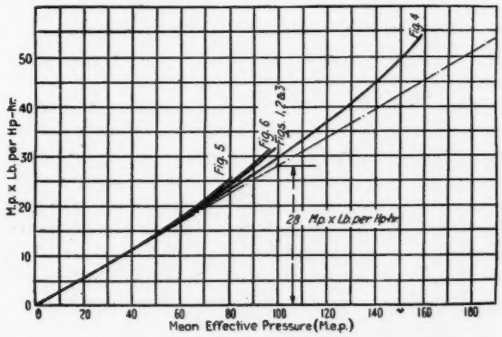


FIG. 2. COMPILED M.P. × LB. PER HP-HR. CURVES TAKEN FROM SIX TESTS ON DIFFERENT ENGINES

Supposing the brake fuel consumption, but not the indicated consumption at different loads, to be known, the author gives examples of the application of the facts deduced, in obtaining the indicated consumption. His first example is an American-built 4-cycle air-injection

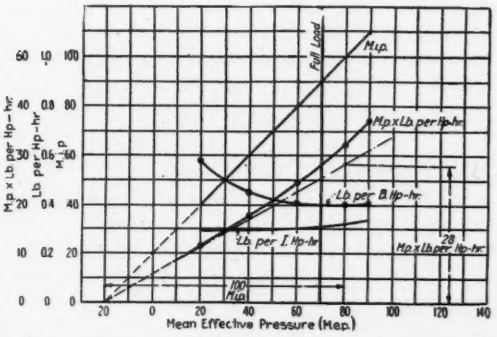


FIG. 3. RESULTS ON AN AMERICAN 4-CYCLE AIR-INJECTION ENGINE

engine of 17 in. bore, running at 200 r.p.m. whose test results were as follows:

M.e.p.	Fuel per b.hp-hr., lb.	M.e.p. × lb. per b.hp-hr.
20	0.580	11.6
40	0.445	17.8
60	0.405	24.3
80	0.405	32.4
90	0.410	37.0

These values have been plotted in Fig. 3, as shown by the points in circles. The m.p. × lb. per hp-hr.

*Chief Engineer of Oil Engines, De La Vergne Machine Co. Abstract of paper presented at annual meeting of A. S. M. E., New York, December 3 to 7, 1928.

curve is continued to the left as a broken line which cuts the abscissa axis at an angle whose tangent is

$$[28 \text{ (m.p.} \times \text{lb. per hp-hr.)}] \div 100 \text{ (m.i.p.)}$$

and at a point —20 m.e.p., which is the friction load. Through the same point, the m.i.p. line is drawn at an angle of 45 deg. The fuel consumption in lb. per i.hp-hr. is then calculated by dividing the values of the m.p. x lb. hp-hr. curve by those of the m.i.p. line.

Conclusions of Author

The fuel consumption in lb. per br.hp-hr. rests on two factors: 1. The consumption in lb. per i.hp-hr. which expresses the efficiency of combustion; and 2, the friction losses which may be expressed in mean pressure and which show the mechanical efficiency.

The indicated-fuel-consumption curves of all examples are compiled in Fig. 4, and extended to an m.i.p. value at which the indicated consumption becomes 0.34 lb. per i.hp-hr. The curves show that the indicated consumption at low m.i.p. approaches 0.28 lb. for all

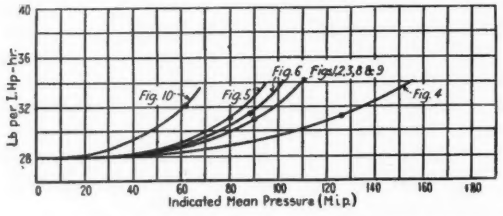


FIG. 4. COMPILED INDICATED FUEL CONSUMPTIONS

engines. The remainder of each curve depends chiefly upon the relative quantity of air in the cylinder. In the case of a crankcase-compression engine lack of air is noticed at a lower m.i.p. than in the case of an engine having a large scavenging air pump while an engine in which scavenging air enters after the closing of the exhaust ports shows still higher m.i.p. capacity, almost equal to that of 4-cycle engines. Supercharged engines go far beyond those not supercharged in this respect.

In the curves of Fig. 4, the commercial full-load rating, as shown by the small circles, lies at about 0.315 lb. per i.hp-hr. Such rating is evidently good practice and might be suggested as a basis for the rating of engines in general. It implies a clear exhaust and desirable overload capacity. It is assumed that the manufacturer provides the necessary mechanical construction and cooling to make the engines reliable at this load. The point at which this indicated consumption of 0.315 lb. is reached is easily determined without use of indicator cards by the method described provided brake fuel consumptions over part of the load range are known.

Friction loads vary widely; the 4-cycle air-injection engines show friction loads of 18 to 20 lb. per sq. in. mean pressure. These are very low values giving mechanical efficiencies of 79.5 and 78.5 per cent at a rating of 70 lb. m.e.p. The 4-cycle solid injection engines show 16 to 13 lb. per sq. in. respectively. This is in line with the values for air-injection engines because the difference of about 5 lb. per sq. in. between them is accounted for by the air compressor. A high-speed engine has a friction load of 30 lb. per sq. in. mean pressure; a supercharged engine having 23 lb. per in. and a 2-cycle engine, 13 lb. per sq. in. In this last engine the scavenging air is furnished from outside, while in a 2-cycle engine with attached scavenging pump showed a friction load of 21 lb. per sq. in. against 18 lb. per sq. in for a crankcase-compression engine.

There is not sufficient regularity in these values to warrant drawing general conclusions from them but it is evident that standards could soon be established were the friction losses more generally analyzed and compared.

Sea Water Used in Zeolite Process

REGENERATION of zeolite for water softening by the use of sea water has been recently successfully accomplished by the Permutit Co. Analysis of the sea water used gave the following results:

		Parts per million	Grains per gal.
Total hardness	Calculated as $CaCO_3$	6420	375
Calcium hardness	Calculated as $CaCO_3$	1170	69
Magnesium hardness	Calculated as $CaCO_3$	5250	307
Chlorides	Calculated as Cl	19080	1130
Sulphates	Calculated as SO_3	2040	119

Results, as to quality of softened water, obtained so far are the same as when pure salt is used for regeneration. The only effect is that the amount of soft water which a cubic foot of zeolite produces is considerably reduced, therefore more zeolite must be employed for a given capacity for sea water regeneration than when pure salt is used for that purpose.

Furthermore, the brine has to be filtered if the sea water happens to be dirty and regeneration with it will be lower, therefore greater excess of brine must be employed. Since, however, the brine has practically no value in most cases where sea water is available and pumping costs are low, the use of a large excess of sea water is perfectly feasible.

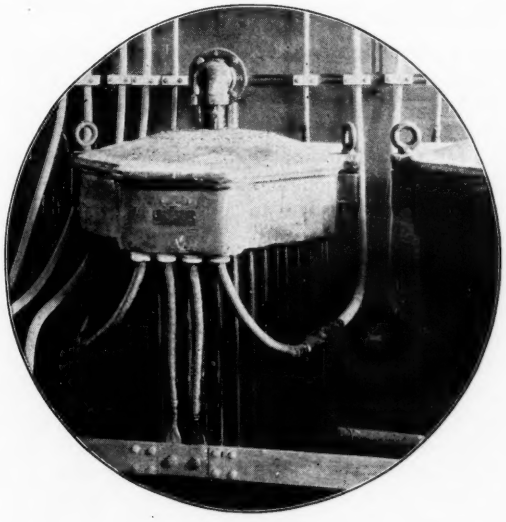
Another High-Pressure Boiler for Lakside Station

Approximately $1,500,000 will be expended by the Milwaukee Electric Railway & Light Co. this year, it is announced in expansion of the boiler capacity and auxiliary equipment at its Lakeside power plant. A boiler operating at a pressure of 1390 lb. per sq. in. and costing $725,000 is the chief item in the program. This boiler will be similar to the high-pressure boiler installed at Lakeside two years ago. It will generate 300,000 lb. of steam an hour at a temperature of 750 deg. Expanding first in special high-pressure turbines and then in machines of normal pressure, the steam from the new boiler will develop energy equivalent to 40,000 hp. This boiler will serve to match the steam capacity with that of the electrical generating equipment, which was increased to about 235,000 kw. last year by the addition of two turbine generators, one of 60,000-kw. and one of 7700-kw. rating.

To house the new boiler, an addition will be built, another to the switchboard building; expansion of coal handling equipment and miscellaneous smaller improvements make up the rest of the budget.

Care of Transformer Installations *in* Industrial Plants

By E. Ogur
Consulting Plant Engineer



THERE EXISTS A PREVAILING notion that transformer installations in industrial plants require no attention whatsoever. This notion probably has been brought about by the fact that compared with other equipments, the attention they require is negligible. But just because the maintenance attention is negligible, is no reason why it should be reduced to absolute zero, until something happens; for when "something does happen," it is usually accompanied by considerable expense and trouble which is inexcusable for the reason that it could have been easily prevented by giving the transformers the little maintenance attention they require.

Difficulties encountered in the operation of transformers may be due to the following causes:

a. Direct lightning stroke,
b. Induced surges due to lightning discharges and other causes,
c. Frequent overloads of prolonged duration,
d. Deterioration of the dielectric strength of the oil.

The first two causes are rarely responsible for transformer operating difficulties in industrial plants. The distance through which the power is transmitted is relatively small and well shielded by neighboring buildings. The secondaries and the casings are effectively grounded. The third cause is seldom responsible for trouble in an industrial plant. Transformer capacity is relatively inexpensive and the tendency is to install oversize transformers, rather than to operate transformers overloaded. This leaves the deterioration of the dielectric strength of the oil as practically the only cause of transformer breakdown in industrial plants.

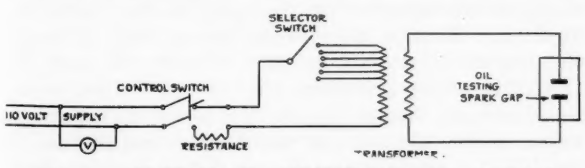


FIG. 1. DIAGRAM OF CONNECTIONS FOR TESTING TRANSFORMER OIL

Requirements of Transformer Oils

Before transformer oil may be safely used, it must be tested in accordance with the standards of the A. I. E. E., N. E. L. A. and A. S. T. M. The test consists of placing a sample of the oil in an insulating cup having two electrodes 1 in. in diameter placed 0.1 in. apart. Voltages of 15 to 25 kv. are applied to the electrodes in steps of 2500 v. until the gap is arced over. The oil is rated as follows:

Rating	Withstands	Breaks down
Unsatisfactory	.....	17,500 volts
Doubtful	17,500 volts	20,000 "
Satisfactory	20,000 "	22,500 "
Good	22,500 "	25,000 "
Excellent	25,000 "	.....

Oil furnished with transformers has a rating of GOOD, at least; that is samples of it withstood a voltage of at least 22,500 v. It does not, however, remain in that condition long.

The dielectric strength of the oil is greatly affected by the presence of minutest traces of water and other impurities, such as metallic dust, etc. The presence of less than 2 parts in 100,000 parts by volume is sufficient to render the oil unsafe, as shown on Fig. 4.

Moisture and other impurities find their way into

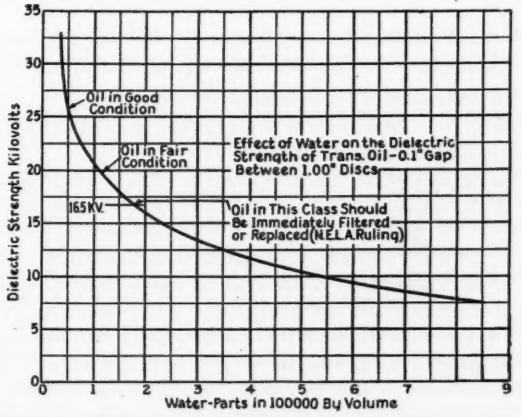

Dielectric Strength Kilovolts
Water-Parts in 100000 By Volume
Oil in Good Condition
Oil in Fair Condition
Effect of Water on the Dielectric Strength of Trans. Oil-0.1" Gap Between 1.00" Discs
16.5 KV.
Oil in This Class Should Be Immediately Filtered or Replaced (N.E.L.A. Ruling)

FIG. 2. EFFECT OF WATER ON THE DIELECTRIC STRENGTH OF TRANSFORMER OIL

the oil by the "breathing" of the transformers. That is, the transformer carrying a load warms the oil, causing it to expand and expel the air above the oil. Upon cooling the oil contracts, admitting air contaminated with moisture, iron and aluminum dust, etc., from the surrounding atmosphere.

To insure the safe operation of transformers, the condition of the oil must be ascertained at reasonably frequent intervals. The N. E. L. A. recommends that oil samples from power station and substation apparatus be tested at every three months. Oil showing a dielectric strength of less than 17,500 v., should be immediately replaced with oil having a dielectric strength of at least 22,500 v.

It is not necessary to scrap the oil of low dielectric

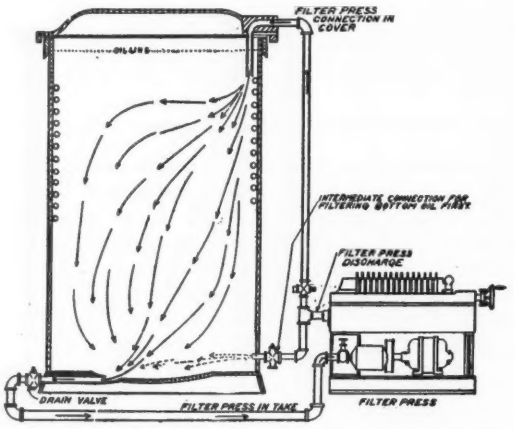


FIG. 3. OIL DRYING APPARATUS IN OPERATION WITHOUT INTERRUPTING SERVICE

strength. It may be reconditioned by filtering and drying by means of apparatus shown in Fig. 3.

Equipments for testing and reconditioning transformer oil are rather expensive and their use is limited to large installations. Small installations have to avail themselves of outside facilities. Samples of the oil may be tested at a very reasonable cost in numerous testing laboratories, or in the laboratory of the manufacturer of the transformers. When found defective, the oil should be replaced by fresh oil. It seldom pays to have the oil reconditioned. The defective oil may be utilized for several purposes, particularly in oil fired boilers or heat treatment furnaces.

Trouble Occasioned by Neglect of Transformer Installation

As an instance of unnecessary trouble and expense incurred by inattention to transformer oil the following experience may be of interest:

In an industrial plant having a total load of about 200 kv-a. located within about 150 ft. from the power house, two unaflow engines direct connected to 160-kv-a., 2300-v., 3-phase generators were installed. The power is transmitted a distance of about 150 ft. where a transformer vault containing five 100 kv-a. transformers are housed. Three of the transformers are connected in delta-delta 2300 to 440 v. for power, and two are connected in open delta primary, single phase, secondary, 2300 to 230/115 v., for light. Four more 100 kv-a. transformers are scattered through the plant. Just what the designers had in mind when they decided on generating 200 kv-a. to be transmitted a distance of 150 ft., at 2300 v., and connecting 900-kv-a. transformer capacity to a total generating capacity of 320 kv-a., is difficult to understand. They might have have had perfectly good reasons for it. Who knows?

About 3 years ago, two of the power transformers in the transformer vault broke down. Two new transformers of a different manufacture were secured and the defective transformers shipped to the original manufacturer for reconditioning. They were repaired and reinstalled without a thought as to the reasons for the breakdown and the measures to be taken for preventing such occurrences in the future. The two transformers of different manufacture were kept as spares. About two months ago two of the power transformers broke down again. An electrician known as an "expert" in transformer installation practice was called in. He disconnected the defective transformers and connected the two spares in their places, without testing out the polarities. As the original transformers happen to be of the "subtractive" polarity, while the two spare were of the standard polarity, it is a miracle that the plant was not wrecked by the repeated attempts to operate with the wrongly connected transformers. The "ex-

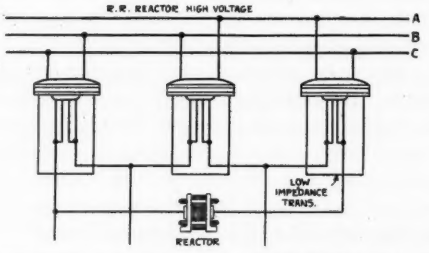


FIG. 4. SHOWING METHOD OF CONNECTING REACTOR TO TRANSFORMER

pert" finally decided that the third transformer is also defective and cut it out, which permitted the plant to operate in open delta on the two spare transformers. The management decided that it may be worth while to call in someone qualified to check the installation, with a view of preventing the recurrence of the trouble. Tests performed indicated that the difficulty was due to the deterioration of the oil in transformers to a dielectric strength of 6000 v. in one and 8000 in the other. The oil in the third transformer had a dielectric strength of 11,000 v., but the transformer was not damaged. The oil in one of the spare transformers was of low dielectric strength. The oil in the third transformer and in one of the spare transformers was changed and the three transformers connected in delta after being carefully tested out for polarity.

The third transformer happened to possess a lower impedance than the two-spare ones. While the three transformers operated satisfactorily at low loads, at high loads the third transformer showed signs of excessive heating. To overcome this difficulty, the installation of a coupling reactor, Fig. 4, was contemplated. But inasmuch as the load on the power transformers never exceeds 150 kv-a., it was decided that the use of two 100-kv-a. transformers in open delta primary is most economical and satisfactory. The third transformer is

kept in reserve. Should a breakdown occur in one of the transformers in open delta, the third transformer could be connected in less than 15 min. The difference in the impedance characteristics will not prevent from operating them in open delta.

Had samples of the transformer oil been taken and tested every six months and the oil found defective replaced, all the trouble and expense would have been saved. But it wasn't a case of negligence. It was simply ignorance on the part of the operating force as to the proper care of transformers. Ignorance in engineering is not bliss.

Design and Operation of Generator Air Coolers

PART II.* FURTHER DISCUSSION OF DETAILS OF DOUBLE-BANK COOLER AND METHODS OF DESIGNING AND OPERATING IT. BY E. WAINWRIGHT JOHNSTON†

ADVANTAGES of using a surface or closed-type generator air cooler in a closed duct system have been pointed out and the operation of the cooler described. The closed type cooler was divided into three classes and the advantages of each were discussed. In the present article, it is the intention of the writer to go a little more into detail in the design of the double bank coolers (one of the three classes discussed in Part I) to show how the heat losses should be distributed between the two banks to obtain the best results from the smallest and least expensive unit.

As described in Part I, a double-bank generator air cooler is divided into two tiers, each consisting of one or more cooler sections. The upper tier uses condensate and the lower raw water for a cooling medium. The air passes through the two tiers in series, being cooled by the warmer condensate first and allowing the cooler raw water to do the remaining cooling.

SIZE OF THE CONDENSATE BANK

In most double-bank installations, the condensate bank is designed to do the larger part of the cooling at full load in order that the condensate may remove as much heat as possible and return it to the boiler. Although for a given water inlet temperature the air gives up heat more readily at high ranges of temperature, there is a limit as to how large the condensate bank should be to recover the most practicable amount of heat. In other words, as the air passes the first few rows of tubes in the condensate bank, it gives up far more heat than it liberates to the rows containing the same surface, which it passes later on. As the temperature of the air lowers, the air becomes more and more reluctant to give up its heat and each successive row of tubes absorbs less and less, until the question arises as to how many rows of tubes it is worth while to install.

This, of course, depends upon the conditions in each individual case. In some cases it pays to do the entire amount of cooling in the condensate bank and in others only 60 per cent. It is seldom wise to do much less than 60 per cent in the average case.

Let us now consider the raw-water bank. In this tier the cooling is completed. If the air is cooled from 150 deg. F. to 115 deg. F. in the condensate bank at full load, the raw water bank cools from 115 deg. F. to 104 deg. F. At part load conditions, the quantity of condensate falls off rapidly, whereas the heat loss reduces much more moderately. Consequently, more work is thrown on the raw-water bank as the load decreases until, at no load, the raw-water bank is doing the entire cooling. It is true that the temperature of the condensate at inlet to the cooler occasionally falls off at the lower loads but this does not make up for the reduction in quantity. The no-load condition, therefore, is the load at which the raw water bank is ordinarily operating at its maximum capacity; it is for this load, therefore, that it is designed.

PROPORTIONING THE CONDENSATE AND RAW-WATER BANKS

We shall now consider a double-bank unit designed to do half the total full load cooling (or less) in the condensate bank. In a cooler so designed, both banks are working at maximum capacity at the full load conditions, therefore the no-load condition is no longer the designing load of the raw-water bank.

When the designing load of the raw-water bank changes from no load to full load, the available air temperature range is greatly reduced. This reduces the mean temperature difference and requires more cooling surface in spite of the lower heat loss.

Probably the reader will be surprised to learn that the surface necessary to add to the raw water bank is greater than that deducted from the condensate bank by decreasing the heat to be absorbed in the latter and adding it to the former. This is true in spite of the fact that the quantity of circulating water available for the raw water bank is limited only by a reasonable water pressure drop and that its inlet temperature is much lower than that of the condensate. The total overall surface for the entire cooler, therefore, is greater for operating conditions where the condensate bank does so little cooling at full load that the raw-water bank is compelled to operate at maximum capacity.

In the above case, in addition to the increase in surface and an accompanying increase in cost, the operator is not recovering as much heat and returning it to the boiler as he could in a smaller unit properly designed.

Such a condition as just described occurs when the specifications state that part of the condensate from the main turbine shall be used in a double-bank cooler serving an auxiliary generator, the condensate passing in parallel through the condensate bank of the main generator cooler and that of the auxiliary cooler.

What the designer really should have in this case, unless he finds he is actually reclaiming enough additional heat (due to the condensate coming in contact with hotter air) to make the additional first cost worth while, is a single-bank, raw-water cooler to serve the

*Part I appeared in the February 15, 1929 issue.
†Engineer, The Griscom-Russell Co.

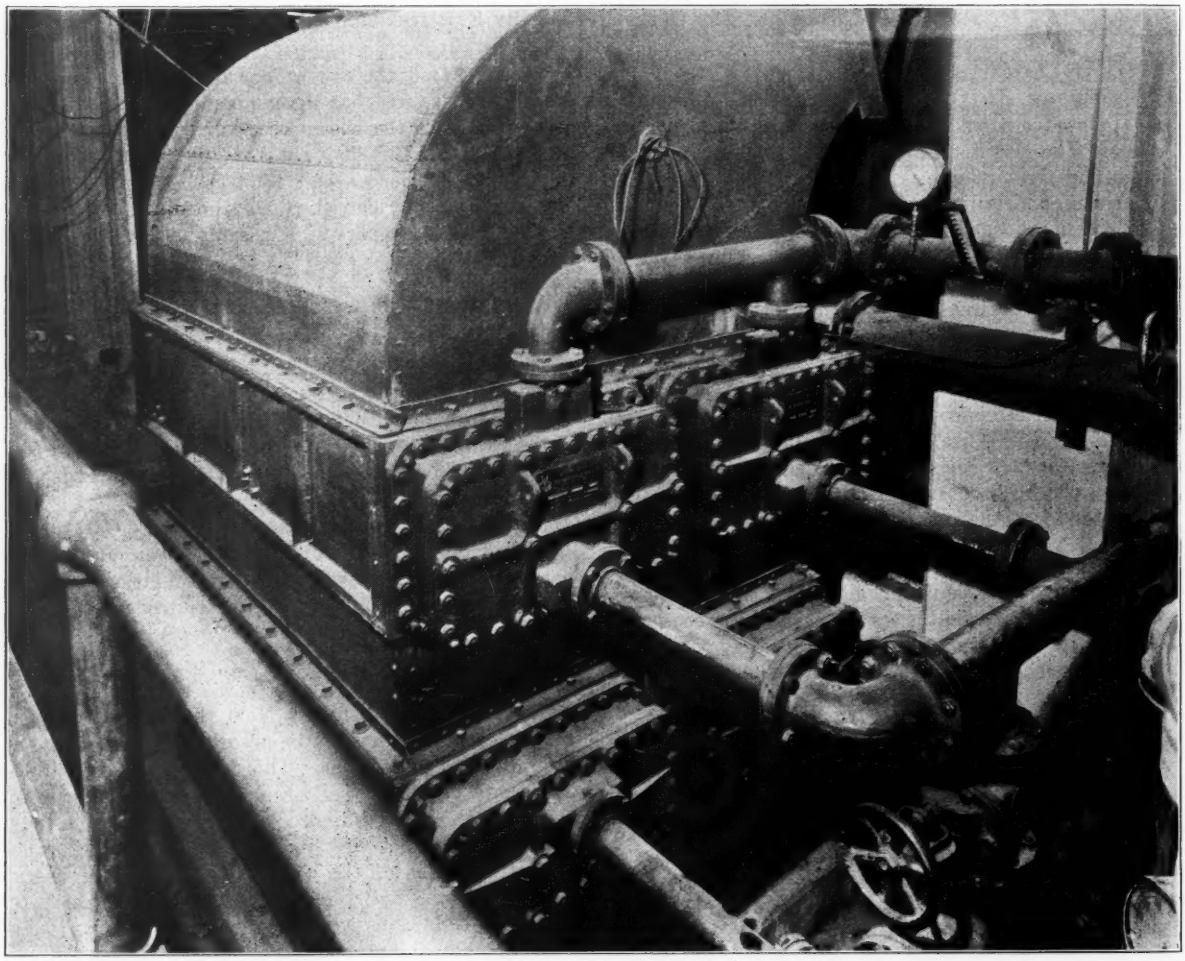
auxiliary generator and a double-bank cooler using both condensate and raw water for the main generator. Both of these coolers will be greatly reduced in surface (therefore in cost) as compared to those which would be installed if his idea was carried out.

Often specifications state that both banks shall be of the same size. This again forces the designer into the situation explained above, resulting in an oversize unit recovering less heat.

Sometimes the specifications will call for cooling the air to a temperature as low at part-load conditions as it is cooled at full load. This is unnecessary and needlessly increases the surface of the raw-water bank, which handles the major part of the work at the lower loads, since it decreases the mean temperature difference (as explained above). If the higher air temperature on leaving the generator is not injurious at full load, it certainly will do no harm at part load conditions.

The foregoing has explained why the size of the double-bank cooler is increased by doing too little cooling in the condensate bank. The writer has emphasized this, as many engineers do not realize that it actually requires more surface.

It is evident, of course, that the surface of the condensate bank will increase with an increase in the amount of heat it eliminates. As soon as the condensate bank does just enough of the total cooling at full load so that the raw-water bank is no longer operating at its maximum capacity at this condition, we have the smallest surface possible which can do the work. The condensate bank may be doing 58 per cent or 78 per cent of the total cooling when this occurs, depending upon the conditions but, whatever the percentage is, if it should increase above this point, the surface of the condensate bank would naturally increase and would do so without greatly affecting the surface of the raw-water bank, since the no-load condition now determines the surface of the latter. As the condensate bank is so increased in surface more heat is reclaimed and, as stated above, we finally reach a point where it is no longer worth while to add surface for the sake of recovering more heat.



DOUBLE-BANK COOLER ON 5000-KW. GENERATOR; COOLER LOCATED OUTSIDE OF GENERATOR FOUNDATION

It may be that the entire full-load loss can be dissipated in the condensate bank without using an exorbitant size unit; again, it may only pay to recover such heat as possible when the condensate bank does only 60 per cent of the total cooling at full load. This depends greatly on the conditions of operation and can best be decided by the designing engineer.

(To Be Concluded)

Electricity---What It Is and How It Acts*

PART XIX. THE EDISON EFFECT. FURTHER CONSIDERATION OF METALLIC CONDUCTION AND EFFECT OF TEMPERATURE. THERMIONIC EMISSION. BY A. W. KRAMER

HAVING CONSIDERED the method by which the electron was isolated and measured and having learned something about the fundamental relation of the electron to simple electrical phenomena, we are now in a position to turn our attention to an extremely interesting phenomenon which has been put to great practical use in recent years. This phenomenon is intimately concerned with the action of the electron and although it was first noticed many years ago, it was not until a definite knowledge of the electron was available that its true nature was understood.

Some 45 yr. ago, long before anybody knew anything definite about electrons, Thomas Edison, in developing the incandescent lamp noticed a curious phenomenon which occurred when he placed a small metal plate in the bulb of a lamp in the manner shown in Fig. 1. When the filament became incandescent, Edison found that the plate became charged electrically and if it was connected through a sensitive galvanometer to the positive terminal of the filament, a current would flow. When the plate was connected to the negative terminal of the filament, however, no current would flow. Apparently, the presence of the hot filament in some mysterious way contributed to produce a charge on the plate. This charge was negative, since it left the plate when the latter was connected to the positive terminal of the filament.

That hot bodies produced electrical effects had been known before; indeed, for over a hundred years, it had been known that when a metal is brought to a state of incandescence, the air in its immediate neighborhood becomes a conductor of electricity. At the time Edison noticed the effect, it was considered a curious phenomenon but it could not be explained and for a time nothing resulted from it. It became known as the Edison effect and was forgotten.

FURTHER ASPECTS OF METALLIC CONDUCTION

With this introduction, let us leave this phenomenon for the present and review briefly the theory of electric conduction in solids discussed in an earlier article.[1] It was shown that conduction in solids is due to the interchange of so-called free electrons between the atomic systems of the metals. These electrons have no permanent family ties—they are a restless lot, wanderers who lodge for a time with one atomic family and then becoming restless or bored perhaps, move on to another atomic system.

Compared to the total number of electrons comprising the atomic systems of a metal, these free electrons are only few in number, yet in terms with which we are familiar they are exceedingly numerous. In ordinary metals, the density of these free electrons is approximately 16,000 coulombs per cubic centimeter. A coulomb, it will be recalled, contained over six billion billion electrons, so a cubic centimeter of metal contains about one hundred thousand, billion, billion free electrons!

These free electrons are in constant motion and are continually colliding with one another and with the atoms and molecules of the metal which are also in motion. Temperature, it has been shown, is merely the manifestation of molecular agitation; the greater the velocity of the molecules of a substance and the greater the number of collisions between them, the higher is the temperature of the substance. The free electrons share the motion of the atoms and molecules. The individual velocities of the electrons and atoms at any instant

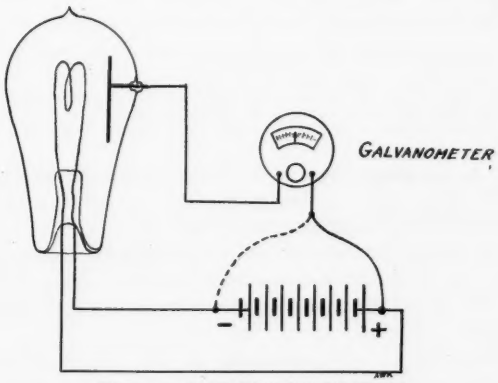


FIG. 1. THE EDISON EFFECT

If the plate is connected, through the galvanometer, to the positive terminal of the filament a current will flow while if the connection is made to the negative terminal no current flows.

differ widely but their velocity as a whole gives an average velocity which is determined by the temperature of the metal. Due to their comparatively small mass, the average velocity of the free electrons is very much greater than the average velocity of the atoms and molecules.

Because of the frequency of collisions of the atoms in a metal, a large number of electrons can be made to move in a definite direction under the influence of comparatively low values of electromotive force. Thus an electric current is produced in the metal. This action has been fully described.

WHAT KEEPS THE ELECTRONS IN THE METAL

Now, a question arises. If it is true, as we know it is, that these electrons are moving about so rapidly, why do they not escape from the metal in which they are active? They possess considerable kinetic energy and it would seem that, so endowed, those near the surface of the metal might actually fly clear of the metal and leave it. The natural answer to this question is, of course, to assume that there exists at the surface of the metal a restraining force which tends to keep the electrons within the substance. Such an assumption was made by O. W. Richardson in 1901 and since it was an assumption, it was not the most satisfactory answer but developments which have taken place since then have

*All rights reserved.

[1]Part IX, September 15, 1928, p. 997.

shown that Richardson's assumption was one which has not led us astray. Recent developments in the theory of atomic structure compel us to believe that such a restraining force must necessarily exist at the surface of substances. In order for an electron to escape from a substance, therefore, it would have to have an amount of kinetic energy sufficient to overcome the restraining force or surface tension of the substance.

Evaporation of Water

A better understanding of this subject may be had if we consider the process of evaporation of water. It is common knowledge that when a vessel of water is exposed to the atmosphere at ordinary temperatures, evaporation takes place and that in time the entire mass of water will have been converted into water vapor. This process of evaporation can be accelerated by heating the water. If it is heated to a sufficiently high temperature the rate of evaporation becomes very great and boiling results.

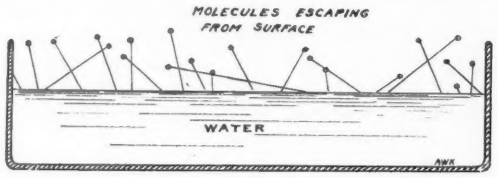


FIG. 2. DIAGRAM TO ILLUSTRATE THE EVAPORATION OF WATER

The molecules near the surface which acquire sufficient velocity are able to overcome the surface tension of the liquid and are projected into the atmosphere or space beyond.

This process of evaporation is due to the thermal agitation of the water molecules. As heat is applied to a vessel of water, the velocities of the molecules increase and the frequency of collision between the molecular systems also increases. Due to the severe impact of collisions, certain of the molecules attain velocities much greater than that of the average. If the molecules which have thus acquired velocities greater than the average happen to be near the surface of the liquid, they may overcome the surface tension of the liquid and be projected out into the atmosphere above the surface of the liquid. Thus they become gas or vapor molecules.

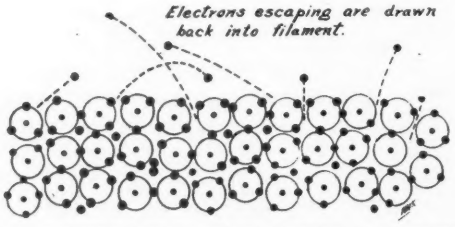


FIG. 3. SHOWING THE "EVAPORATION" OF ELECTRONS FROM A HOT METAL

Known commonly as thermious emission, this phenomenon is similar to the evaporation of water. The thermal agitation of the molecular structure of the metal provides the free electron with sufficient velocity to escape from the metal. The loss of a number of electrons in this manner leaves the hot metal with a positive charge, which acting upon the electrons draws them back into the metal.

As the temperature of the liquid is raised, the average velocity of the molecules becomes greater and more molecules attain velocities great enough to carry them out of the liquid.

What is true of water in this respect is true also of other substances such as metals. The molecules and atoms of metals when heated to high enough temperatures also attain velocities sufficiently high to enable them to escape from the surface of the body, thus resulting in evaporation of the metal. The number of atoms thus liberated or what is the same thing, the rate of evaporation, depends upon the temperature and the latent heat of the particular metal under consideration. Of course evaporation of metals occurs at temperatures very much higher than that of water but the principle involved is the same.

Evaporation of Electrons

Now, it is logical to suppose that if atoms are able to acquire sufficient velocity to overcome the surface tension at the surface of a metal, the free electrons also might be able to do the same thing.

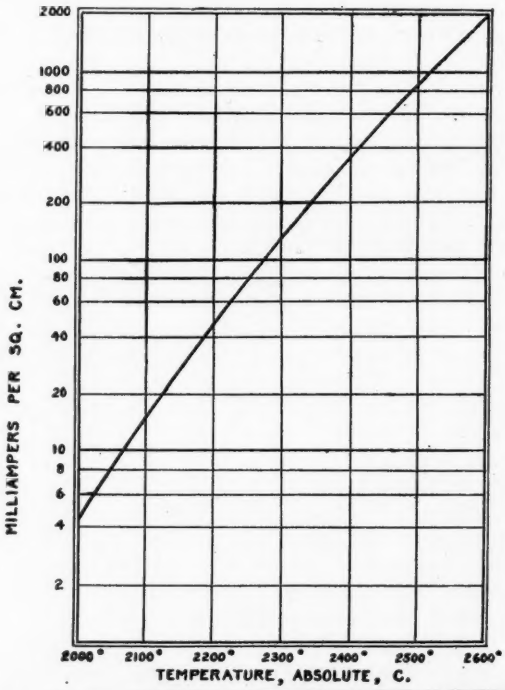


FIG. 4. GRAPH, SHOWING HOW THE ELECTRON EMISSION FROM TUNGSTEN VARIES WITH TEMPERATURE

In this case the electron emission is given in milliamperes. The number of electrons actually emitted can be obtained by merely multiplying the number of milliamperes by 6,280,000,000,000,000.

This actually is what occurs. At high temperatures, the molecular activity of both the atoms and free electrons is greatly increased and certain of the free electrons acquire sufficient velocity to enable them to overcome the restraining force at the surface and they are thus projected out into space. As early as 1899, J. J. Thomson had shown that negative electricity was given off from the hot filament of Edison's lamp in the form of electrons but the mechanism of this emission was not known until O. W. Richardson, in 1901, showed that the electrons are emitted solely by virtue of their kinetic energy.

The action is very much like that of the evaporation of water which we have described. The free electrons in a metal behave much like the molecules of a

gas; that is, they move about at velocities which depend upon the temperature of the metal. At ordinary temperatures very few electrons in the more common metals possess sufficient kinetic energy to overcome the surface tension at the boundaries of the body and the number of electrons escaping at such temperature is negligibly small.

At any particular moment, some electrons will have zero velocity while others will have extremely high velocity. The majority, however, will have velocities ranging between the two extreme values of speed. It is only those few electrons with the extremely high velocities that are able to escape through the surface.

The evaporation of electrons from metals occurs at a lower temperature than that at which evaporation of atoms occurs. This is due to the fact that the average

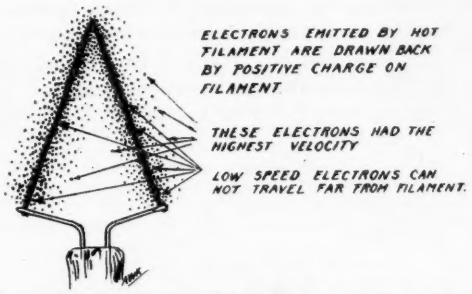

ELECTRONS EMITTED BY HOT FILAMENT ARE DRAWN BACK BY POSITIVE CHARGE ON FILAMENT
THESE ELECTRONS HAD THE HIGHEST VELOCITY
LOW SPEED ELECTRONS CAN NOT TRAVEL FAR FROM FILAMENT.

FIG. 5. SHOWING THE EFFECT OF THE FILAMENT UPON THE ELECTRONS

After an electron has escaped from the filament by virtue of its kinetic energy, the filament is left with a positive charge and the electron is drawn back into the filament again. Thus, a swarm of electrons remains in the vicinity of the filament which decreases in density with increase of distance from the filament. Only the highest velocity electrons ever reach the outer layer of this electron swarm.

velocity of the electrons is much higher than that of the atoms. Naturally, therefore, we would expect to obtain a copious emission of electrons at a temperature considerably lower than the boiling point of the metal and such is the case. Figure 4 shows how the electron emission from tungsten varies with temperature.

Phenomenon Is Basis of Many Developments

The phenomena, at first regarded merely as an interesting fact, is responsible for some of the most startling developments in the realm of electricity, for it is the foundation of the modern radio industry. Without electron emission from hot filaments, there would be no radio vacuum tubes and without vacuum tubes there would be no radio broadcasting and receiving as we know it today. From this it should not be inferred, however, that the vacuum tube is absolutely essential to the production of radio waves, but by its use the production of these waves is so simplified that its advent has revolutionized the art of radio.

Electron emission also plays a major part in other developments, such as the x-ray, the cathode ray oscillograph, and alternating current rectifiers. Transcontinental telephony is made possible because of it. Before discussing these applications, however, it will be necessary to study more in detail, the further consequences of this electron evaporation from hot metal surfaces.

While the chart in Fig. 4 showing the theoretical electron emission indicates that great numbers of electrons are emitted at a temperature well below the melting point of tungsten[2] in an ordinary lamp, for instance, no such numbers are emitted. This is due to the fact that the electrons thrown out are drawn almost immediately back into the filament again. When an electron leaves the surface of the filament, the latter is left with a positive charge and so attracts the escaping electron. There are, therefore, almost as many electrons falling back into the filament as are expelled.

Effect of a Positively Charged Plate

Suppose, however, that in addition to the filament there is inserted into the bulb a small metal plate such as Edison used and that this plate is given a positive charge by connecting it with the positive terminal of the lamp filament. Thus an electrostatic field will be established between the filament and the metal plate. Under these conditions an electron when it has been ejected from the filament will be acted upon by a combination of forces, one tending to draw it back towards the filament and another tending to draw it to the positively charged plate; the strongest force, naturally, will

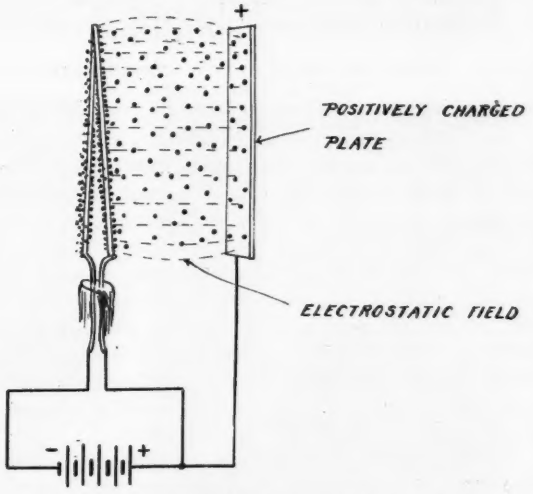


FIG. 6. THE EFFECT OF A POSITIVELY CHARGED PLATE UPON THE ELECTRON

With this arrangement, the electrons, after being expelled are acted upon by the electrostatic field between the plate and the filament and as a consequence are drawn toward the former.

draw the electron towards it. So, by impressing a high enough positive potential on the plate, it will be possible to draw the electrons away from the filament toward the plate just as fast as they are emitted by the former. In this manner, a current is established which flows from the hot filament to the plate, through the external circuit to the positive pole of the battery, and through the battery to the negative terminal of the filament.

In this case, the battery furnishing the energy to create the electric field is the same as that used to light the filament but if desired a separate battery could be used as shown in Fig. 7. Usually, if it is desired to remove all the electrons being emitted from the filament, a separate battery is necessary since a higher potential is required than can be supplied by the filament lighting battery.

[2] 3400 deg. C.

As might be expected, the number of electrons which leave the filament is affected by the atmosphere in the bulb. If there is gas in the bulb, the electrons leaving the surface of the filament can not travel far without colliding with the heavy atoms of the gases. For this reason, the emission can be facilitated by exhausting the gases from the bulb so that only a very low pressure remains. In a perfect vacuum, the electrons would encounter no heavy gas molecules and their progress would be unimpeded.

Here, then, we have a new method of producing electric conduction in gases or even in a perfect vacuum. In Part VI[3] of this series of articles, we showed how an electron current was established by the presence of free electrons or ions in the space between two oppositely

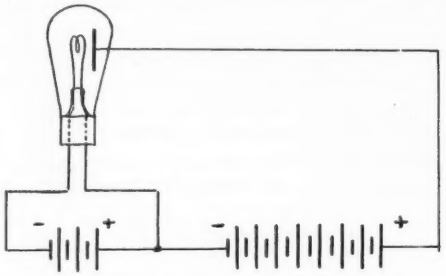


FIG. 7. ANOTHER METHOD OF CONTROLLING THE ELECTRON CURRENT
In this case a separate battery is used to establish the field between the filament and the plate.

charged plates. In the chapter on insulators and conductors[4] it was shown also that if the potential gradient through a dielectric is made high enough, a current will be established due to the rupture of the normal atoms into positive and negative components. Now, however, in the phenomenon we have just described we have at our disposal a more effective method of producing conduction through gases, for it is seen that by means of a hot filament or other form of cathode an electron current can be produced by boiling out, so to speak, the electrons in the filament itself.

These currents produced by incandescent cathodes have come to be known as thermionic currents, since the emission is the result of thermal agitation of the molecular structure of the cathode.

Since this study of thermionics deals directly with the electron in its "raw" state, it will be of considerable interest to discuss some of the more common applications of this principle in subsequent articles.

[3]August 1, 1928 issue, page 828.
[4]Part X, October 1 issue, page 1041.

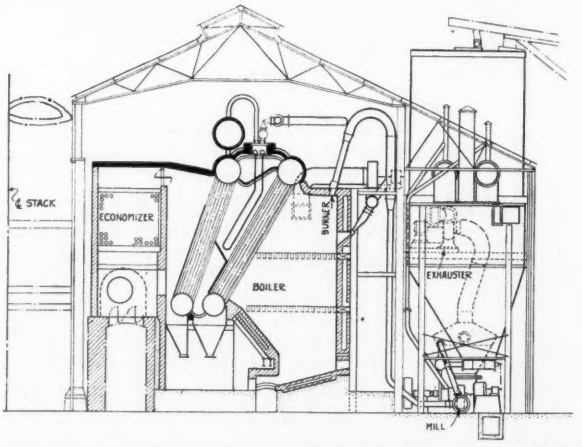
Burning Colliery Waste in Pulverized Form

PULVERIZED COAL fired boilers, designed to utilize coal refuse, which formerly had been disposed of at some cost in slurry pits, have recently been installed by the Cadeby Colliery in England. The installation, recently described by Engineering of London, consists of three Thompson 118-lb. (570 deg. F. total temperature) 6970-sq. ft., five-drum water-tube boilers with 1330-sq. ft. superheaters and a Green tri-tube economizer with 194 tubes 13 ft. long. Each boiler is rated at 30,000 lb. of steam per hour normal, or, 45,000 lb. per hr. maximum.

Wall and floors are of hollow wall, panel type construction, the 9-in. space in them being used to heat the secondary air. Ash is removed by a water-sealed drag scraper at the bottom and a small oil burner is provided in each furnace for lighting up the burners when cold.

Fine coal from the screening plant is delivered to the green coal silos, shown in the upper right-hand corner of the cross section, by a 12-in. belt conveyor. These cylindrical silos are of unusual construction being built up from flat tongue and groove slabs of concrete measuring 30 by 12 by 2½ in. These are bound externally by steel hoops which are provided with lugs for the screw tightening device. The external diameter is 16 ft. and the height 20 ft.

From the silo, green coal descends through the discharge gates into an automatic weighing machine and then to one of two 12,000-lb.-per-hr. Holbeck pulverizers driven by 75-hp. motors. The 70-t. pulverized coal bin is situated between the two green coal silos. The exhauster fan driven by a 30-hp. motor discharges the



CROSS SECTION OF THE BOILER PLANT AT THE CADEBY COLLIERY

coal into this bin which is fitted with vanes to give a cyclone effect. The air is then recirculated to the pulverizer.

Burners are of the low velocity Hay type with the mouth of the burner formed of a casting lined with fire brick. Inside this are two hinged cast-iron flaps covered on the back with fire brick. These flaps can be adjusted from the outside while the boiler is operating and serve to regulate the burner opening and direction of the flame so as to protect the walls. Records show the water consumption to vary from 22,000 to 66,000 lb. per hr., the demand being irregular because of the hoisting engine load. The coal runs about 10,662 B.t.u. per lb. about 21 per cent ash and 4 per cent moisture.

RECENTLY, the Kalamazoo Vegetable Parchment Paper Co. at Kalamazoo, Mich., put into operation two new 1000-hp. Wickes, three-drum boilers with economizers. These boilers are fired by Taylor stokers and have American Engineering Co. water walls, Ljungstrom air heaters, Hagan combustion control and an Elliott feedwater heater. The electric generating equipment consists of a 7500-kw. General Electric extraction turbine exhausting to a 9800-sq. ft. C. H. Wheeler condenser.

Hydro Development in New England

United Electric Light Co.

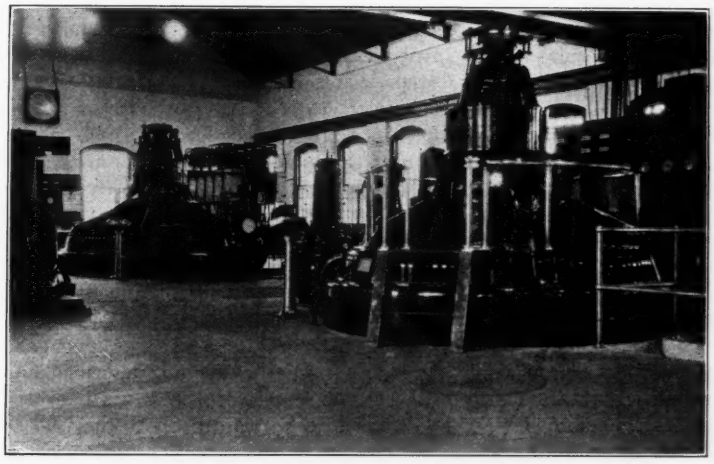
Completes

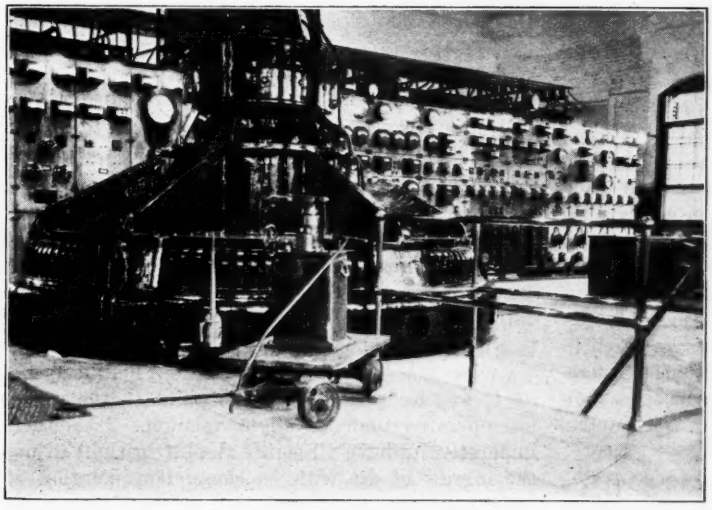
Indian Orchard Plant

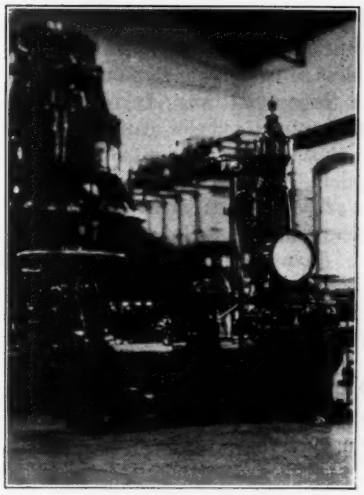
at

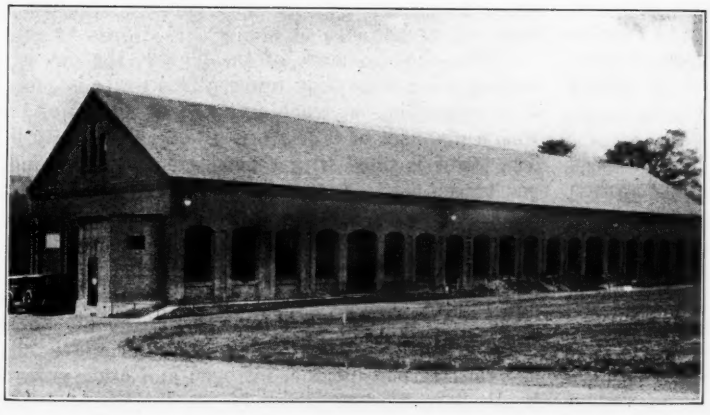
Springfield, Mass.

TWO NEW UNITS have recently been added to the Indian Orchard water power plant of the United Electric Light Co., following complete electrification of the textile mill of the Indian Orchard Co. Previous to March, 1928, when full rights were purchased, the Indian Orchard Co. had prior use of the water, the United Electric Light Co. using only the flow above the requirements of the mill.









The new equipment consists of two Rodney Hunt Machine Co. water wheels with Lombard Governor Co. governors driving Westinghouse Elec. & Mfg. Co. direct connected generators and exciters. One of these units, shown in the top view, is a 3000-hp., 200 r.p.m. wheel driving a 2750-kv.a., 5500-v. 80 per cent power factor, 2-phase, 60-cycle generator and 275-amp., 125-v. exciter. The second new unit consists of a 2000-hp., 240-r.p.m. wheel driving a 1875-kv.-a. generator and a 170.5-amp. exciter.

Both machines are designed for a head of 44 ft. and replace two Holyoke McCormick units which had been in service many years.

Manufacture of Dry Ice or CO_2 Snow

Carbon Dioxide Snow Is Used for Many Purposes. This Article Describes the Principles and Methods Involved in Its Manufacture. By N. H. Hiller*

MANUFACTURE of carbon dioxide snow, to the trade usually known as "Dry Ice," involves three separate and distinct steps, each of which requires certain apparatus more or less involved in manufacturing detail functions. The three steps mentioned may be classified as follows: First, the manufacture and preparation of the carbon dioxide gas in a clean, pure and dry state; second, the liquefaction of the carbon dioxide gas and third, the expansion of the liquid carbon dioxide forming carbon dioxide snow and the pressing of this snow into cake form.

Carbon dioxide gas, the chemical formula of which is CO_2, is found abundantly in nature but in such a form as to be practically useless for any commercial processes. Certain metals may react with carbonic acid in nature to form carbonates and the reaction of alkali forms bicarbonates accordingly. The existence of the vegetable kingdom is due almost entirely to this gas. The roots of every plant absorb the gas in its watery solution. This watery solution is obtained by the precipitation of moisture through the air, thus picking up and holding in solution the carbon dioxide gas always present in air. It is a peculiar fact that the very gas which is so life-giving to plants is that which is liberated from the animal lungs during the process of breathing. Every animal exhales carbon dioxide with the breath and this carbon dioxide is the life of the vegetable kingdom.

Carbon dioxide is also found freely in nature, in geysers and gas wells. Certain mineral waters contain large quantities of this gas which may be liberated through application of heat. Furthermore, it may be found in the natural or artificial fermentation of vegetable substances and in fermentation processes. Carbon dioxide may be produced by chemical reactions through the applications of acids and various carbonates and finally it may be produced through combustion in the ordinary form.

It is this last method upon which we will concentrate. The products of any perfect combustion are carbon dioxide and nitrogen, together with certain volatile constituents of the fuel. In normal combustion, however, we generally allow an excess quantity of air to exist in the furnace with the result that the flue gases contain not only carbon dioxide and nitrogen but a certain per cent of oxygen as well.

Commercial Production of CO_2

As a general practice in the production of carbon dioxide gas for process work, a boiler fired with suitable type stoker is usually employed. By utilizing an underfeed type of stoker, the maximum percentage of CO_2 may be obtained in the furnace, if proper attention has been paid to the matter of setting. Regarding the type of boiler which may be used, this matter is of little consequence except that sufficient furnace volumes should always be allowed. The usual type of return tubular boiler should be so arranged that at least 6 ft distance for proper combustion is allowed between boiler and stoker retort bottom. Should the Stirling or similar type of boiler be used, however, a much greater furnace volume can be had with little increase in the size of setting. It is advisable also to furnish suitable tuyeres above the retort so that additional air may be admitted to the combustion chamber, thus insuring a better combustion of the fuel. The steam generated in the steam boiler may be used in the plant to operate the compressor and to furnish make-up steam in the lye boiler. Suitable forced draft provision must be made and in addition to the usual stack, which in a CO_2 plant is used only for starting, a provision for conducting the flue gas through further processes as hereinafter described must be made.

In order to reduce the temperature of the flue gas to the very lowest possible point, a fact which will permit conservation of water, a superheater, feedwater heater and air preheater may very well be employed. In addition to this apparatus, the flue gas may be used in a heat exchanger to assist the heating of the lye used further in the process.

Cleaning the Gas in the Scrubbers

After leaving the boiler, the flue gas is conducted to a scrubbing tower or series of scrubbing towers, the capacity of the plant determining whether one or more scrubbers shall be used. Here the flue gas travels from bottom to top of a tower which is filled with limestone and over which water is allowed to trickle removing dust and other impurities from the flue gas. At the gas outlet at the top of the scrubber, the gas is conducted to another scrubber, if necessary, and then the coil and clean gas is led to the suction end of a high duty blower.

It will be seen that to this point the entire system has operated under a slight vacuum. It is therefore imperative to have all joints absolutely tight to prevent the ingress of air with its consequent polution of the carbon dioxide gas. After leaving the blower, however, the system operates under a slight pressure, excluding any possible chances of loss of capacity through polution.

From the discharge of the blower, the gas is conducted to an absorption tower. This tower is generally of considerable size, reaching perhaps a height of 100 ft. with a diameter of 8 or 10 ft. in a large capacity plant. The tower is filled with a good grade of coke and the gas enters at the bottom, meeting a stream of sodium carbonate or potassium carbonate lye sprayed from the top. Both sodium and potassium carbonates, the latter particularly, have great affinity for carbon dioxide and when cool, around 100 deg. temperature, can absorb large quantities of this gas. At the top of the tower is an outlet to the atmosphere through which all unabsorbed carbon dioxide, nitrogen and other gases may be discharged. The strong lye, as the lye now charged with carbon dioxide is called, is conducted from the

*The Vilter Manufacturing Co., Milwaukee, Wis.

absorption tower through a heat exchanger the functions of which will be explained later. The strong lye is here raised in temperature and is piped to the lye boiler where steam coils, utilizing the exhaust steam from the engine driving compressor, liberate the carbon dioxide for further operation. The weak lye, or lye from which carbon dioxide has been expelled, is returned to the absorption tower through the heat exchanger and atmospheric type cooling coils.

Process Involves Delicate Heat Balance

Inasmuch as the entire process is a very nice heat balance, considerable detail must be observed in the utilization of all otherwise waste heat. For this reason, heat exchangers are used and furthermore a lye preheater may be located in the boiler flue after the superheater and economizer in order to obtain more heat in this process. In fact, the use of heat exchange apparatus is imperative to the success of a carbon dioxide snow plant. The matter of fuel requires considerable attention as well, only the best grade of gas house coke with a sulphur content of ½ per cent or less being used.

From the lye boiler, the carbon dioxide gas, now entirely pure but at a very high temperature, is first conducted to atmospheric type condenser coils, usually of the bleeder pattern. Here, the temperature is reduced and a large quantity of moisture removed through condensation. The pure gas is then further dried by passing through a calcium type dehydrator to produce an absolutely dry gas. We have now reached the end of the first phase in the manufacture of carbon dioxide snow, namely the production of a pure, clean, dry, carbon dioxide gas.

Liquefaction Process

The second phase, or the liquefaction, will now be considered. The gas on leaving the calcium dehydrator is under a very slight pressure due to its liberation in the lye boiler. It therefore may be piped in steel pipes in the usual manner, thus preventing all pollution through the entry of air. A gasometer is utilized as a storage tank from which a suction line is led to a suitable compressor.

For the liquefaction of any gas, the compressor used requires considerable engineering attention. For liquefaction pressures of 1000 lb. to 1500 lb., a three stage compressor is generally employed. Suitable intercoolers must be placed between the various stages, otherwise the heat of compression would be so great as to cause considerable injury to the valves, pistons and cylinders. We may consider the suction pressure on the compressor to be approximately 5-lb. gage and the discharge pressure for normal water temperatures to be at least 1000-lb. gage. Various engineering concerns make suitable compressors for this service and all of these may be had in a steam driven type. The steam generated by the steam boiler mentioned at the beginning of this paper may be used to drive the compressor and the exhaust from this steam engine is conducted to the lye boiler. At the end of compression, the carbon dioxide gas, now under excessive pressure, is condensed in double pipe or other type of condenser similar to that used in current refrigerating practice. The carbon dioxide gas is here liquefied and may be placed in a suitable storage tank or filled into standard carbonic acid containers. So much for the second phase or liquefaction of the carbon dioxide gas.

Turning the Liquid Into Snow

The third phase, or the operations necessary to change the liquid carbon dioxide to carbon dioxide snow in cake form, will now be discussed. The liquid carbon dioxide may be fed into the snow chamber, the chamber used for making carbon dioxide snow, either from a suitable storage tank or directly from carbonic acid containers. For even operation of the plant, however, it is a better policy to use a large container as the reservoir of supply. A standard form of snow chamber may be constructed as follows: A cylinder of steel is fitted with a suitable cover carefully welded on and containing one or more gas outlet holes at the top, properly screened. The bottom of this cylinder is connected directly to the cake forming chamber wherein the carbon dioxide cakes are pressed into shape. At suitable locations near the bottom of the snow chamber are located discharge nozzles through which the carbonic acid is expanded, forming during the expansion the carbon dioxide snow required. The gas liberated due to expansion is allowed to leave the chamber through the discharge holes in its top and is conducted back to the supply gasometer for recirculation through the liquefaction apparatus. Beneath the snow chamber is the cake forming chamber aforementioned.

Forming the Cakes

This apparatus consists mainly of a cylinder open at both ends, a piston operating through one end under hydraulic pressure and a movable cylinder head held in place by a hydraulic ram at the other end. In operation, the process is as follows. The cylinder head is held in place by means of hydraulic pressure and the piston is drawn back the full length of its travel. The snow formed during expansion falls of its own weight into the cylinder and when sufficient snow has collected, this being determined through operation and practice, the piston is used to form a snow cake compressed under hydraulic pressure. After the cake has been thoroughly compressed, the cylinder head is backed off and the cake expelled from the cake forming chamber. It is not necessary to turn off the supply of carbonic acid to the snow chamber during this process, inasmuch as upon the return of the piston to its normal position and the replacing of the cylinder head, the entire cycle is continued.

The foregoing will give a brief outline of the carbon dioxide snow without going into complete details of all processes involved. It must be borne in mind that there is considerable knowledge of chemistry necessary in the correct operation of such a plant and although it would seem an intricate proposition to handle, the actual operation may be carried out with a very few employes, a fireman, an engineer, a snow chamber operator and a roustabout helper, being all that is required.

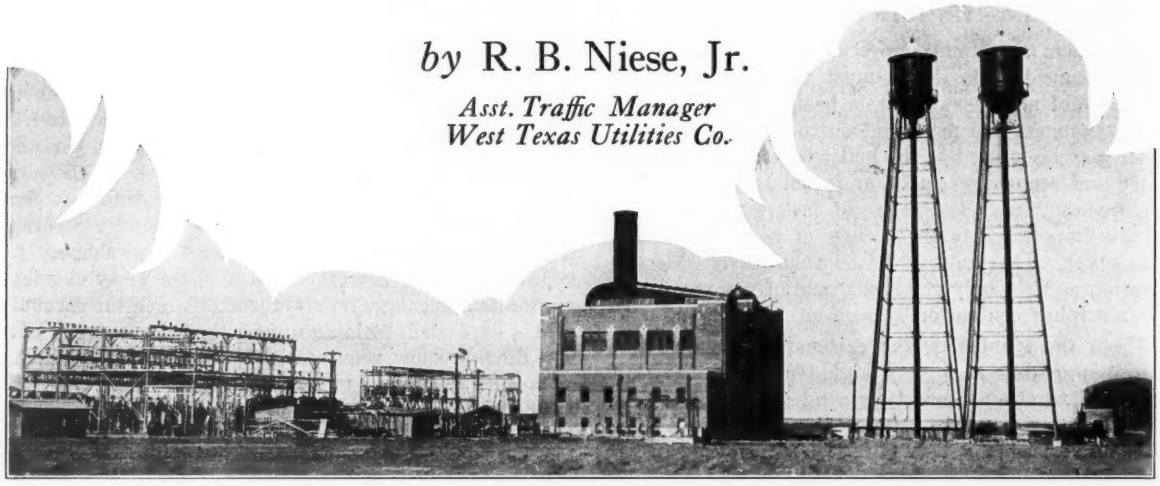
Gulf Public Service Co., Jacksonville, Texas, is arranging an expansion program for 1929 to include installation of a 2500-kv-a. turbine generator, 500-hp. boiler and auxiliary equipment, also a new ice plant and extensions in transmission lines from Rusk to Alto.

Gas Makes Ideal Fuel at

LAKE PAULINE

by R. B. Niese, Jr.

Asst. Traffic Manager
West Texas Utilities Co.



WHAT IS BELIEVED to be a time record for the erection of a power plant was established when, on September 10, the 18,750-kw. generating station of the West Texas Utilities Co. was put into operation. This station, located at Lake Pauline, 6 mi. northeast of Quanah, Texas, was completed in 6 mo., without overtime, with laborers working only during daylight hours.

West Texas Utilities Co. has a connected system of transmission lines measuring 2000 mi., serving 105 cities, towns and communities in West Texas with light and Power. This new station increases the available generating capacity of the company to over 52,000-kw. In this section of the state, water for circulating purposes is limited and Lake Pauline, covering an area of over 600 acres, constructed a number of years ago as an irrigation project, presented the only available site. A spur track, approximately 3 mi. long, connects the plant with the main line of the Fort Worth & Denver City Railroad.

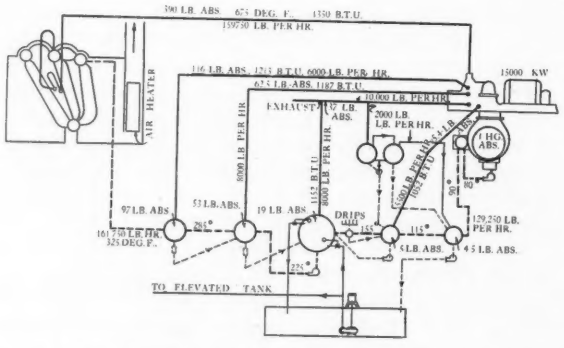


FIG. 1. FLOW DIAGRAM OF LAKE PAULINE STATION OF THE WEST TEXAS UTILITIES CO.

Fuel for the plant is supplied by the Lone Star Gas Co. through an 8-in. high-pressure gas main connecting with their Panhandle gas field. As auxiliary fuel, fuel oil, stored in a 10,000-bbl. storage tank, will be used.

Work on the plant, which was designed by Sargent & Lundy, Inc., was started February 13, 1928, by Robert E. McKee, general contractor for the building, machinery foundations and flume excavation. The building foundation consisted of Chicago wells and concrete slab. The concrete slab formed the basement floor and except for outside walls and turbine foundation, the framework of the building from the basement slab to the roof is of steel. Steel framing was begun at the basement floor level so that if pulverized coal should ever be used in this plant, the necessary furnace changes could be made with the least amount of alterations.

Building measures approximately 110 ft. by 145 ft. The exterior is finished in a red brick while the interior of the boiler room is finished in a buff glazed brick and the turbine and operating rooms in a dark glazed brick wainscot with light face brick walls. The floors in the boiler and turbine rooms are of granite terrazzo and the floor in the operating room and office is of rubber tile.

Switch Track Enters the Turbine Room

There is no wall between the boiler and turbine rooms. Boilers face the outside east wall and immediately behind them are the heaters and evaporators, adjoining the turbine room. The operating room is on the west side of the turbine room. Extension to the plant is to be made on the south, a temporary end wall of steel and 4 in. of brick being constructed for this

purpose. A switch track enters the turbine room on the north. The turbine room is equipped with a Whiting four-motor-driven Bridge Crane of 65-t. capacity with an auxiliary hoist of 10-t. capacity. Mosher Steel and Machinery Co. furnished and erected the structural steel and stack, while the galleries, floor plates, steel stairs and miscellaneous iron was furnished by the Vierling Steel Works.

Boiler plant consists of three 1000-hp. Stirling boilers built to operate at 400 lb. steam pressure and 350 per cent rating. They are equipped with Babcock and Wilcox superheaters designed for 250 deg. F. superheat. Sturtevant motor-driven "TurboVane" forced draft fans with a capacity of 38,750 c.f.m. each at 3-in. static pressure draw the air through baffled side walls of the furnace, delivering it, through Babcock and Wilcox 11,222-sq. ft. tubular air heaters, into the gas and oil burners through steel ducts under the furnace floor. Green Type RR motor-driven induced draft fans with a capacity of 59,700 c.f.m. at 5 in. static pressure take the flue gas through the air heaters and pass it into a steel stack, 10 ft. 5 in. in diameter extending 53 ft. above the roof. One stack serves the three boilers. The boiler settings were installed by the L. M. Beall Construction Co., while the M. H. Detrick Co. furnished the air-cooled bridge walls, air-cooled side walls and arches.

Each boiler has nine Bendster combination oil and gas burners, so constructed that it is not necessary to replace the burners when changing from gas to oil or vice versa. Gas is delivered to the burners at 18 lb. gage pressure. A fuel oil storage tank of 10,000-bbl. capacity and a small auxiliary oil tank were furnished by Wyatt Metal and Boiler Works. This contractor also furnished air ducts and flues.

Oil unloading is done with a Quimby motor driven screw pump with steam jacketed cylinder and is delivered to the burners by two Quimby fuel oil pumps driven by Terry steam turbines. These pumps have a capacity of 16,000 lb. of fuel an hour. The oil is heated

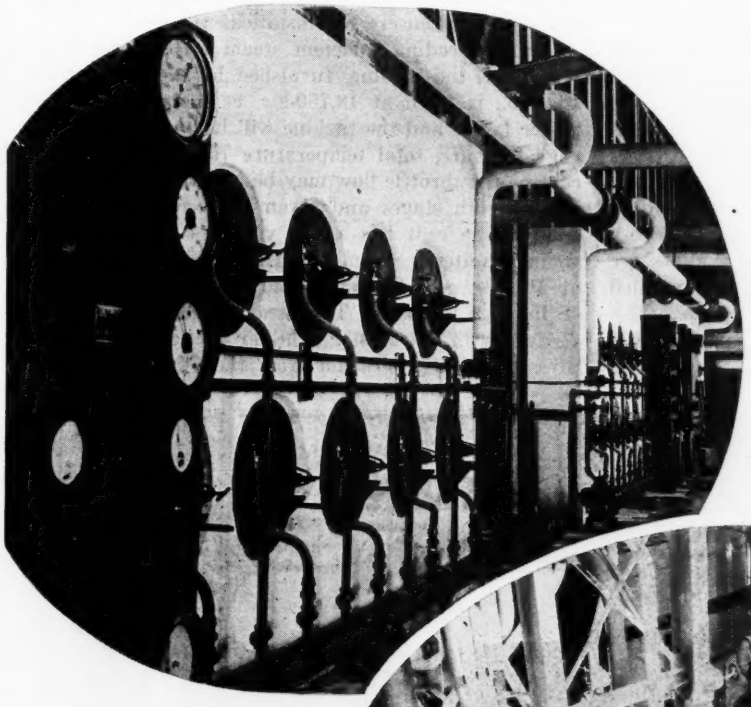


FIG. 2. (LEFT) BOILER FRONTS SHOWING THE ARRANGEMENT OF THE GAS AND OIL LINES TO THE BURNERS. EACH BOILER HAS NINE BURNERS SO ARRANGED THAT THEY CAN BE USED FOR EITHER GAS OR OIL. BRIDGE WALLS, SIDE WALLS AND ARCHES ARE ALL AIR COOLED.

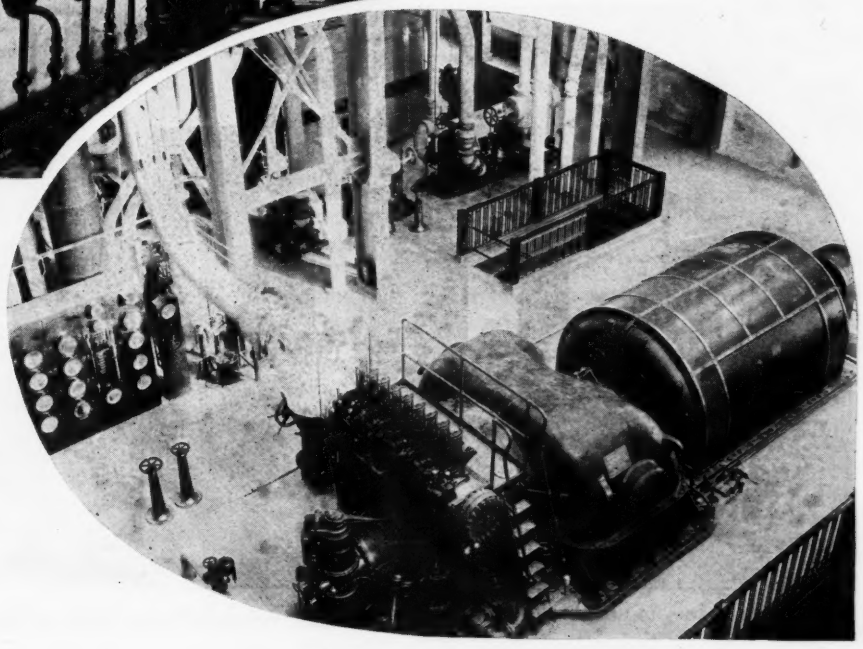


FIG. 3. (RIGHT) TURBINE GENERATOR OF THE LAKE PAULINE STATION. THERE IS NO PARTY WALL BETWEEN THE BOILER AND TURBINE ROOM

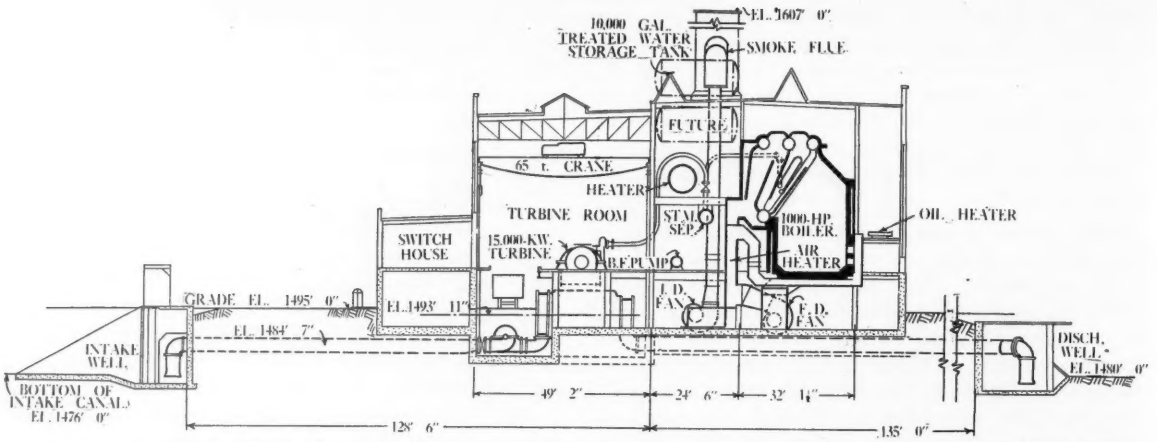


FIG. 4. CROSS SECTION OF THE LAKE PAULINE STATION SHOWING THE ARRANGEMENT OF EQUIPMENT

in a Griscom-Russell, five-pass, horizontal, straight tube heater.

Condenser Tubes Expanded at Each End

Circulating water flows from the lake south of the plant through an open flume into the intake well, located 50 ft. from the building. The water, handled by a 36,000-g.p.m. Foster-Wheeler motor driven circulating pump, passes through the 17,000 sq. ft., single pass Foster-Wheeler condenser, under the boiler room slab to the discharge well on the opposite side of the building. A canal carries the water from the discharge well to a neck of the lake northeast of the plant. The tubes are of arsenical copper, No. 18 B.W.G., 1 in. O.D., expanded at both ends with one tube sheet floating.

An external air cooler of 2000 sq. ft. is used in connection with the condenser. Duplicate Foster Wheeler 192,000 lb. per hr. two stage hot well pumps, direct connected to 40 hp. induction motors, and a Foster Wheeler twin 34 c.f.m. steam jet air pump with inter and after condensers, are installed.

When bleeding sufficient steam for heating its own feedwater, the turbine, furnished by the General Electric Co., is rated at 18,750-kw. capacity, 100 per cent power factor and the turbine will be operated at 375 lb. gage pressure, total temperature 700 deg. F. Ten per cent of the throttle flow may be extracted from the 1st, 4th and 6th stages and seven per cent from the 11th stage. The unit has a 250 v. direct connected shunt wound exciter. Steam is extracted from the 1st stage at 101 lb. gage pressure and from the 5th stage at 48 lb. gage pressure. This steam is used in heating the feedwater in two Foster Wheeler vertical U bend high-pressure heaters. Steam from the 6th stage at 22 lb.

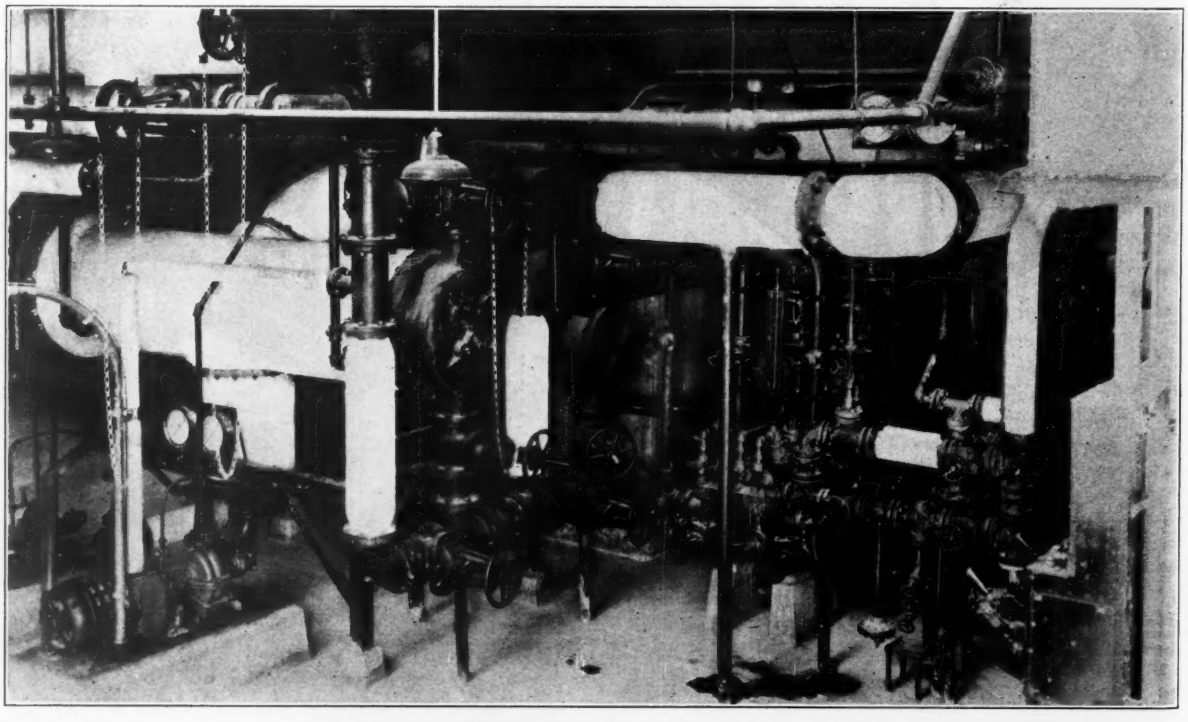


FIG. 5. CONDENSER AND TURBINE ROOM AUXILIARIES

gage pressure maintains 5 lb. gage pressure in the Cochrane direct contact open type horizontal deaerating feedwater heater and also furnished steam for the double effect submerged coil Foster Wheeler contraflow evaporator. Steam from the 11th stage at 5.4 lb. absolute is used in a Wheeler horizontal floating head low-pressure heater. Details of the flow diagram are shown in Fig. 1.

TOTAL FEEDWATER TEMPERATURE 325 DEG. F.

With 1-in. abs. condenser pressure and at full load, it is estimated that the condensate will leave the condenser at 80 deg. F. and pick up 10 deg. F. in the air cooler, 25 deg. F. in the low pressure heater, 40 deg. F. in the evaporator condenser, 70 deg. F. in the open heater, 60 deg. F. in No. 1 high pressure heater and 40 deg. F. in No. 2 high-pressure heater, entering the boiler at 325 deg. F.

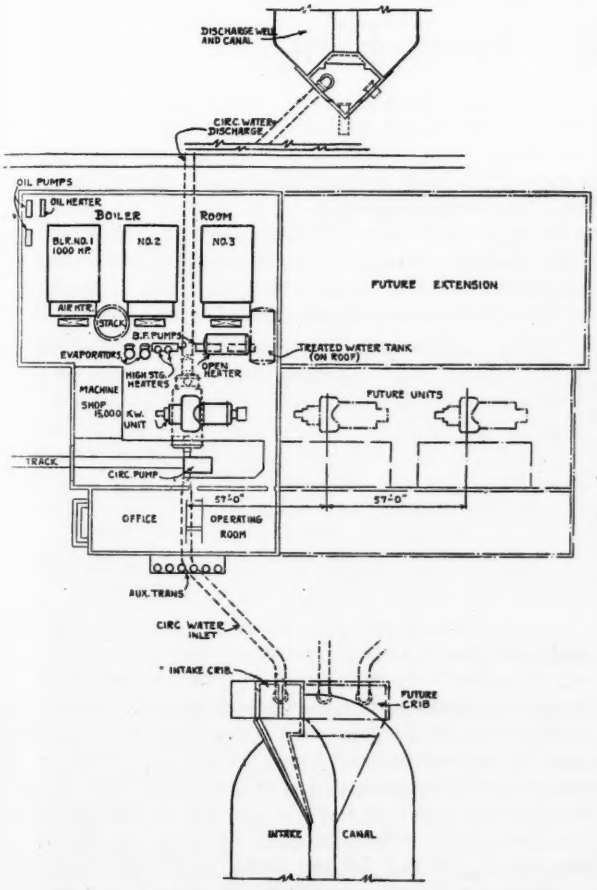


FIG. 6. PLAN OF THE STATION SHOWING THE PROPOSED LOCATION OF FUTURE EQUIPMENT

Feedwater is handled by three Cameron centrifugal pumps; one motor driven, six-stage pump and one Terry turbine driven six-stage pump, each with a capacity of 250 gal., and one five-stage, Terry turbine driven pump, with a capacity of 500 gal. Service water is handled by two Cameron centrifugal pumps of 400 g.p.m. each directed connected to Fairbanks-Morse motors. The Chicago Bridge and Iron Works furnished two 25,000-gal. tanks on 125 ft. towers, one of which is used for service water and the other for distilled water. The raw water for this plant is treated in an International Filter Co. zeolite water softener before evaporating.

Piping connections were installed by the Urbauer-Atwood Co. Sarlun patented joints are used in the main and auxiliary steam lines, while in the smaller steam lines and boiler feed piping, male and female joints are used. Steam and boiler feed line gate valves were furnished by the Walworth Co.; non-return valves, globe valves, check valves by the Edward Valve & Mfg. Co.; Crane Co. motor driven circulating water valves by the Crane Co.; excess pressure valves and pump regulators by the Mercon Regulator Co.; Copes boiler feedwater regulators by the Northern Equipment Co.; uptakes and air ducts by Wyatt Metal and Boiler Works; insulation for the air ducts and uptakes by Johns-Manville, Inc., and the pipe covering by The Standard Asbestos and Insulating Co. Compressed air

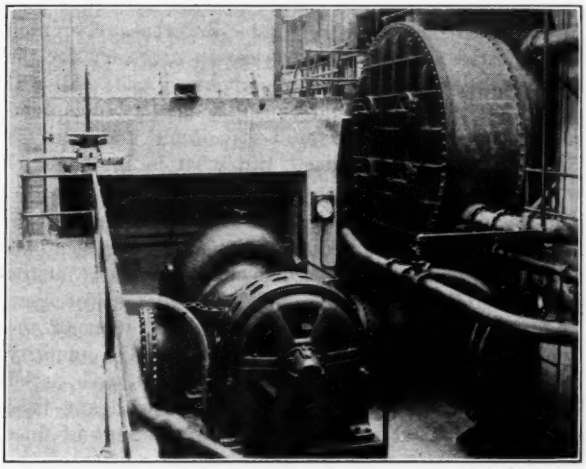


FIG. 7. THE 17,000-SQ. FT. SINGLE PASS CONDENSER IS SUPPLIED WITH WATER BY A 36,000-G.P.M. PUMP

is supplied by an Ingersoll-Rand two-stage air compressor with a capacity of 425 cu. ft. per min. This compressor is connected by a Texrope Drive to a 125-hp. Fairbanks-Morse, ball bearing motor.

Electricity is generated at 13,800 v. and the turbo-generator has a direct connected exciter. The generator is cooled by a three section General Electric surface air cooler, with cooling water taken from the circulating system. The generator is equipped with Westinghouse differential relays which operate a solenoid trip on the turbine throttle. General Electric switchboard and indoor oil circuit breakers are used. The 13.8-kv. substation is equipped with General Electric outdoor circuit breakers and Delta-Star bus supports and switching equipment. Two three-phase 1500-kv-a. Westinghouse transformers are used for station auxiliaries.

Power for this plant is transmitted over two double circuit steel tower lines connected into the company's transmission system on the east and north. The 66-kv. transformer station has a bank of 20,000-kv-a. Westinghouse transformers with one spare. This substation has four feeder circuits and is equipped with transfer bus and tie breakers. Breakers in this station were furnished by the Pacific Electric Co., while the General Electric Co. furnished the potential and current trans-

formers and the four lightning arrestors. The power station is equipped with an automatic telephone system, having 19 telephone locations. An annunciator is installed for complete signalling between the turbine room and switchboard operators.

Bristol recording and indicating thermometers are installed and Republic flow meters are used in the boiler feed lines and gas lines to each boiler. Brown CO_2 meters and Ellison draft gages are used. Builders Iron Foundry Venturi meter is used on the condensate. The turbine room is equipped with a large synchroscope and the turbine room and boiler room each have a master steam gage. The station has a complete machine shop, located in the basement, equipped with an 18-in. American lathe, an 11-in. Southbend lathe, a 24-in. shaper, a Buffalo universal iron worker, a Marvel metal band saw, a 20-in. Rockford drill press, a Clark emery grinder and a Franklin portable crane and hoist.

Approximately one-half of the operating crew will live in a village adjoining the plant, consisting of 12 attractive residences. This village will have a recreation building and the grounds will be appropriately parked and provided with playground equipment. McGinnis & McGinnis of Dallas are the landscape architects.

Pulverized Coal---How Fine?

Is the Demand for High Percentages Through 200 Mesh Justified?

By H. G. Lykken*

THERE IS, as yet, considerable difference of opinion as to the fineness of pulverization necessary for the best results in the burning of pulverized coal. All will agree that the coal should be fine enough to burn completely in the furnace volume available and with as little excess air as possible. But what is fine enough?

More and more engineers are coming to the conclusion that if all the coal passes 50 mesh, standard screen, it will fulfill all the requirements. The specifications for mill equipment then become simple, merely that the product of the mill shall pass 50 mesh standard screen, under all conditions of ratings, state of wear of the grinding parts and condition of the coal. The quantity of superfines, that is material passing 200 mesh, is let be what it may. It is well known that with any type of mill or method of grinding, the percentage of fines will vary greatly with the nature and condition of the coal.

Grinding so that all will pass 50 mesh, a yield of 80 per cent through 200 mesh will be obtained with some exceedingly friable coals, such as New River, especially when dry or when heated air is drawn through the mill, whereas, as low as 30 per cent will be obtained with sub-bituminous coal, particularly if high in moisture. Control of the maximum permissible size can readily be made a mechanical function of any method of grinding. The yield of super-fines reverts back to the nature and condition of the coal that can be equalized only by a tremendous variation in the cost of pulverization.

Furnace Conditions Depend Largely on Large Particles

If 50 mesh is fine enough and the overall efficiency is unaffected by the percentage of super-fines, such a specification is complete as well as simple. There are some engineers who would claim that all passing 40 mesh is satisfactory and the point of highest overall economy, cost of grinding considered. Some may even go a little lower, under the most favorable conditions of furnace design and method of burning.

From the beginning, however, some engineers have insisted on a large percentage of 200 mesh material, and they insist on specifying different percentages through 200 mesh, in many cases a very high percentage with any coal regardless of its nature or condition. Pulverized coal burns in an incredibly short space of time because of its finely divided condition. The natural conclusion was, of course, that the finer it could be divided, the faster and more completely it would burn.

It is claimed that a large percentage of super-fines has a certain value regardless of the greater cost of pulverization, and that a high percentage of super-fines require less furnace volume and can be completely oxidized with less excess air, regardless of the fact that there will be a percentage in any milling system just passing the 50 mesh, or perhaps even coarser, that must have time, distance of travel and space to burn.

Then, is a specification calling for a high percentage of material passing through 200 mesh justifiable?

Unfortunately, there have been no generally acceptable tests made as to the effect of varying percentages of super-fines on combustion. It would be necessary to make such tests with a wide range of coals, covering a wide range of furnace conditions, both as to design, ratings and methods of firing before any definite conclusion could be made. The coal would all have to pass a given mesh, say 50 mesh, at one end of the scale and be fired with definite proportions of minus 200, say 30, 50, 70, 80 and 90 per cent. Until such tests are made, the value of super-fines can only be conjecture. There are so many factors that enter into the efficiency of a given installation that have nothing to do with fineness, that to determine the value of super-fines, it is necessary to make it the only variable in a given test to get a basis for definite conclusions.

Present-day conclusions as to the value of fines is entirely based on setting the mill to grind finer. This, of course, yields a higher percentage through 200 mesh. It does not follow, however, that this higher percentage of super-fines is the advantage. It is more reasonable to suppose that it is the cutting down of the oversize or even the quantity of 50-80 material that improves the furnace condition.

A fairly high percentage of super-fines may be necessary with some methods of firing and some coals, and not at all with others. It is an uncontraverted fact that the younger coals and the higher volatile coals can

*The Strong-Scott Mfg. Co.

be a great deal coarser than many of the older and lower volatile coals, for equally good results.

Value of Superfines Is Mere Conjecture

Grinding finer than necessary is expensive. It may be said that the generally accepted control as to pulverization has standardized on a definite limit as to maximum size tolerated, with a disposition to let the percentage of super-fines be what they may, depending upon the nature and condition of the coal. There are so many eminently successful installations operated on this theory, with apparently nothing to be gained by an upset increase in fineness. There is little to indicate that there can be a saving in furnace dimensions, construction or maintenance. The burden of proof as to the value of super-fines must, therefore, fall on its advocates.

After several years' observation of a great variety of furnaces, kinds and character of coals, and methods of firing, the writer's conclusion is that a high percentage of super-fines adds nothing to the efficiency of combustion, the rate of combustion or any other feature of burning pulverized coal that may have merits in its favor. If all the coal passing 50 mesh (probably 40 or 60 mesh could be used with equal propriety) will completely burn with a minimum of excess air in a remarkably short flame travel, provided, of course, it is properly mixed with the air and properly fired, what more can be asked? If it does this, containing a minimum of super-fines, say 30 per cent passing 200 mesh, why call for more? In fact, the writer has often found that an excess of super-fines delays combustion and there may be good theoretical grounds for such a conclusion.

When coal is to be burned on a grate, the rate of combustion is promoted by crushing the coal. A bed of smaller particles burns faster because the air can be brought in contact with more surface area. There is, however, a limit to which it can be reduced in size; if it is made too fine, the fire will mat and combustion will be retarded.

Some may argue that this is not analogous to the burning of pulverized coal. Yet, it must be remembered that in the pulverized form, coal goes through the same cycle in combustion that it does on a grate. As the coal particle enters the furnace, it must first be heated up till all the moisture is driven off. It must then be further heated up until all the volatiles are driven off. In the place of the original coal particle, we now have two products, a piece or pieces of coke and a series of volatiles. The coke burns as such. The volatiles must be further heated up to the disassociation temperature because they can burn only as their constituent elements, carbon and hydrogen.

Coal Particles Fuse Together

This may all happen in a few inches or feet of furnace travel, yet at some point of the temperature rise, the coking stage is reached when all the coal particles are soft and sticky. Should, at this stage, two or more particles be in contact, there would be a fusion into one piece of coke. Should a large number of particles be in close contact, a large flake of coke would form.

It is well known that finely divided material suspended in a fluid has a molecular attraction and tends to draw together into an agglomerate. The finer the material is divided, the greater is this tendency. It requires no stretch of the imagination to assume that a dense cloud of super-fine coal, entering a furnace, particularly where only a small amount of primary air is used, agglomerates in the coking stage into larger flakes containing hundreds of coal particles and burning as such, and not as the individual particles coming from the mill. Such flakes may greatly exceed in size the largest individual particles coming from the mill and the more finely divided the product, the greater would the tendency be so to agglomerate.

It is hard to account for the large quantity of flake-like ash particles sometimes encountered in the flue gases, particularly when the coal is fed in a dense stream with little primary air, except that they are the skeletons of large agglomerations of coal particles. The ash from the original finely divided coal particles, individually oxidized, would have been colloidal in size. Not infrequently, under furnace conditions where the coal is only partially burned, coke particles may be captured in the passes of the boiler that greatly exceed in both bulk and weight the largest individual particles coming from the mill.

It is highly probable that the best combustion with any product or high volatile lies in the range from 50 to 200 mesh with little or no finer than 200 mesh. Going from 100 mesh to 200 mesh increases the number of particles eight times but only increases the surface area by two. Is it not possible that the increased density of the dust cloud, containing eight times as many particles, may retard the heating-up of the entering coal and air mixture by obstructing radiant heat penetration that would more than offset merely doubling the area? If the tendency of the larger particles to stay in their own atmosphere of air is enormously greater, there is less tendency to agglomerate.

Coal must be pulverized fine enough to burn in suspension with a minimum of excess air. This may be 40 to 50 mesh, may be coarser or finer, depending upon the nature of the coal, furnace, the rating, the method of firing and perhaps other factors in less degree; but as to the quantity through 200 mesh, "why bring that up?"

U. S. Civil Service Commission announces open competitive examination for senior hydraulic engineer, application for which must be on file with the Commissioner at Washington not later than March 6. The examination is to fill a vacancy in the engineering department at large, Cincinnati, Ohio, and other vacancies throughout the U. S. Entrance salaries range for $5000 to $6000 a year and the duties are to assume responsible charge of studies of stream flow, power, navigation and similar problems and include supervision of surveys, mapping and preparation of reports. Full information may be obtained from the Commission at Washington, D. C., or at the post office or custom house in any city.

Cleveland Electric Illuminating Co., Cleveland, Ohio, has authorized an expansion program, involving about $11,000,000 to include an addition to the Avon power plant, with installation of equipment to increase the capacity to 187,000 hp.

A. I. E. E. Winter Convention Brings Out Many New Developments

TO THE PROGRESSIVE electrical engineer in America, no event held during the year is of quite as much importance or holds greater interest than the winter convention of the American Institute of Electrical Engineers, held at the Engineering Societies building in New York City. This meeting is the most important of the national meetings held by the Institute and has never failed to attract a large gathering of notables in the profession, for at this meeting are presented the most recent developments in the field of electrical engineering.

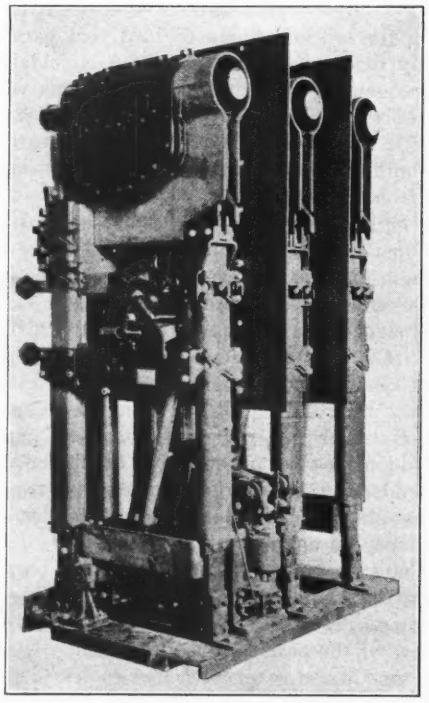


FIG. 1. THE "DEION" CIRCUIT BREAKER

A remarkable new development in circuit breaker manufacture. In principle this breaker consists of a stack of thin metal plates, spaced $\frac{1}{16}$ in. apart. The arc formed by the breaking of the contacts below is forced into this stack by a magnetic field. The arc is broken up into a series of short arcs. Currents as high as 28,000 amp. have been interrupted by this device.

The meeting held this year from January 28 to February 1 was no exception. It drew to its numerous sessions over 1300 electrical engineers from all parts of the United States and on its program of technical papers were included several on developments which will have marked influence in their particular branches of the profession. Of these, perhaps the most interesting was a series of papers presented on the Deion circuit breaker. The Deion circuit breaker is a new breaker for use on alternating current circuits, employing an entirely new principle of extinguishing the arc formed at the contacts. As described in the papers, this device seems to function with remarkable effectiveness and it will, without doubt, find an important application on the alternating current systems in this country.

Another group of papers remarkable in their content, which created great interest, was that presented at the Tuesday afternoon session on Transmission and Lightning. Here it was shown how, by improved apparatus, F. W. Peak, Jr. had succeeded in producing artificial lightning strokes of 5,000,000 v. potential. Not content with prying into nature's secret of producing lightning, the electrical engineer goes into competition with nature and makes very creditable bolts himself.

Besides the technical papers presented, many other events and activities marked this convention. There were inspection trips to a wide variety of plants, laboratories and industries. There was a medal presentation and a popular lecture, and there were social affairs for both men and women.

Dr. Jewett Awarded Edison Medal

Dr. Frank B. Jewett was this year's recipient of the Edison medal, the presentation taking place at the Engineering Societies building on the evening of January 30. Dr. Jewett has been one of the foremost figures in the development of the communication systems of this country and it was for his contributions to the art of electrical communication that the award was made. As transmission and protection engineer of the American Telephone and Telegraph Co., Dr. Jewett was responsible for the introduction of phantom loading, loading of large gage open wire circuits, the practical use of telephone amplifiers and the development of phantom duplex cables. He is now vice-president in charge of research for the A. T. & T. Co. and president of the Bell Telephone Laboratories, Inc.

Dielectrics and Electrophysics

Where dielectrics are concerned, the name of J. B. Whitehead of Johns Hopkins is a familiar one to the members of the Institute and his paper presented jointly with R. H. Martin at the session on dielectrics and electrophysics discussed the theory of dielectric absorption as related to conduction. This paper described in detail a series of experiments on the fundamental properties of a number of waxes and oils, such as are used in composite high voltage insulation. Results seemed to indicate that dielectric absorption is purely a conduction phenomenon, and that the conductivity of dielectrics is highly anomalous in character, sometimes increasing and sometimes decreasing, with increases in voltage and temperature. It was found also that no existing theory can account for the variation in the absorption of mixtures. Temperature elevation increases conduction and is a most serious factor in causing deterioration.

With the increasing need for high voltage transmission and distribution in our metropolitan areas, the development of high voltage cable is of great importance.

That this is so was evidenced by the unusual interest displayed at the session on cables. In discussing progress in high tension underground cable research, G. B. Shanklin and G. M. J. Mackay gave particular attention to the formation of "voids" in the insulation and concluded that void formation under service conditions is inherent in paper insulated "solid" cables. Methods of reducing the size and duration of voids and increasing their pressure were evaluated.

Losses in cable sheath and armor, particularly with single conductor cable received treatment in two papers. Schurig, Kuehni and Buller gave a method for calculating the losses in single conductor armored cable and showed that copper armored cable has a lower annual cost than steel-wire armored cable at load factors above 60 per cent. In a paper on Reduction of Sheath Losses, Herman Halperin and K. W. Miller of the Commonwealth Edison Co. described a new scheme of bonding and a new bonding device.

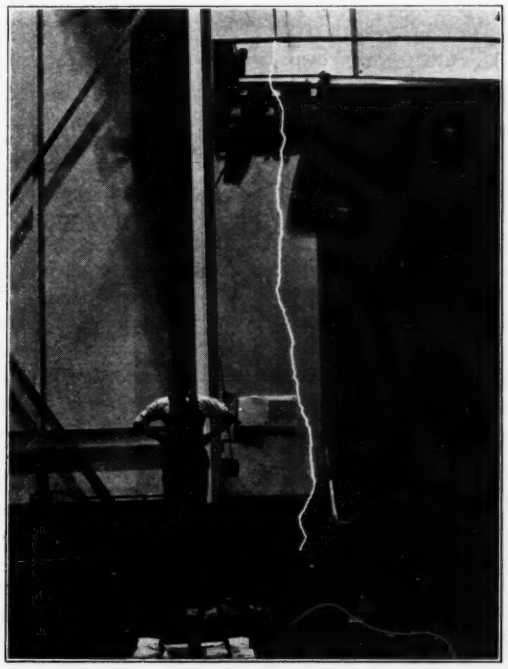


FIG. 2. A FIVE MILLION VOLT "MAN MADE" LIGHTNING DISCHARGE

Lest the reader become concerned about the safety of the man, it may relieve him to know that this is a double exposure, the photograph of the man being made first and then after he had removed himself a photograph of the flash recorded on the same plate.

Transmission and Lightning

One of the most interesting sessions at the convention, as already mentioned, was that on Transmission and Lightning. It was at this session that F. W. Peak, Jr., of the General Electric Co., outlined the progress in lightning research in the field and laboratories. While Mr. Peak's printed paper referred to the production of lightning voltages of 3,600,000, Mr. Peak announced that just previous to his coming to the Convention, he had succeeded in attaining lightning voltages of 5,000,000, this being more than a third again as high as the previous highest voltage electrical discharges obtained in the laboratory. The new method devised by Mr. Peak for producing the 5,000,000 v., is the use of four 1¼-million volt lightning generators in series, so arranged that the voltages of all the generators are added together at the proper instant. By varying the resistances, condensers and inductances, the wave shape can be made to have different characteristics, such as those of lightning. Waves varying in duration from a few billionths of a second to a thousandth of a second, have been used in the experiment. By continuing the series of generator units to include five or more even higher voltage can be produced, said Mr. Peak. Progress in the entire field of lightning research has been extremely rapid. In discussing Mr. Peak's paper, K. B. McEarhron, also of the General Electric Co., showed how, by means of a portable lightning generator set, artificial lightning waves have been impressed on remote points of transmission lines and the result of such artificial flashes measured by oscillographs installed at the terminals of the transmission line. Work on the measurement of actual lightning discharges on high-voltage transmission lines has also been done and E. S. Lee, of the General Electric Company, described a series of experiments which have been made on a transmission line last July. In these experiments, an oscillogram of an actual lightning stroke of approximately 2,500,000 v. was obtained. It was interesting to observe that the characteristics of the actual lightning discharge as obtained by the oscillograph was very similar to the characteristics of the artificial lightning discharge recorded by a similar oscillograph.

Messrs. Fortesque, Atherton and Cox, all of the Westinghouse Electric & Manufacturing Co., presented a paper on Theoretical and Field Investigations of Lightning. Their work in measuring actual lightning discharges was done by means of a Norinder oscillograph. This is a cathode ray oscillograph which is automatically set in action by the impulse of the lightning discharge itself. They also showed an oscillogram of an actual lightning discharge.

Ground Wire Proves of Value

Of further interest to the transmission line engineer was the paper by Philip Sporn, electrical engineer of the American Gas & Electric Co. Mr. Sporn, in his paper, outlined the lightning experiences on 132,000-v. lines of his company during the year 1927. While it is impossible here to go into details in regard to Mr. Sporn's paper, some of his conclusions are interesting. These are as follows: (1) The effectiveness of the ground wire was further established. (2) Some data were obtained that would indicate very definitely the effectiveness of two ground wires when properly employed. (3) It was shown that the ground wire equalizes the lightning voltages on all three wires on a vertically arranged line besides reducing the lightning voltages. (4) The use of properly designed arcing protective devices have, in all probability, resulted in a certain reduction in the number of flashovers and has very definitely minimized cascading when flashovers did finally result. Where cascading does occur, the use of arcing protective devices results in the reduction of damage to such an extent to be of minor importance from an operating standpoint.

The Deion Circuit Breaker

The theory of the Deion Circuit Breaker, as explained by Joseph Slepian to the engineers of the convention, was of extreme interest, as it outlined an entirely new principle of extinguishing an arc formed by two electrical contacts separating. In presenting the theory of this device, Mr. Slepian showed that the electric arc instead of being merely an unpleasant accompaniment of the opening of the switch, plays a very necessary and desirable part and that if the arc did not occur spontaneously on separating contacts, it would have been necessary for us to discover or invent it or its equivalent for the purpose of circuit interruption. Dr. Slepian's preliminary investigations in the theory of the arc had to do with the rate of recovery of the dielectric strength of the arc in changing from a conducting medium to a non-conducing medium.

It was found that the ability to withstand the first few hundred volts was attained almost immediately but that later increments of dielectric strength were recovered at a much slower rate. A study of this action finally led to the development of the Deion breaker.

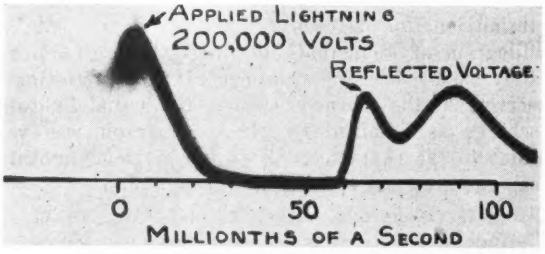


FIG. 3. WHAT HAPPENS WHEN A BOLT OF ARTIFICIAL LIGHTNING STRIKES A TRANSMISSION LINE

Some 60 millionths of a sec. after the bolt strikes, the reflected wave returns from the other end of the line and is recorded by the oscillograph.

A complete description of this breaker will be presented in a separate article.

In the field tests on this breaker, three phase grounded and ungrounded short circuits above 15,000 amp. and at 12,000 v. were interrupted consistently.

Developments in Communication

Thursday morning was devoted to two simultaneous sessions, one on communication and another on electrical machinery. Several papers presented at these morning sessions were of particular interest because they showed how a series of very simple researches can result in considerable economic saving. A paper presented by H. H. Glenn, E. C. Wood, both in the Bell Telephone Laboratory, outlined simple methods by which silk and cotton insulation can be purified and improved. It gave the result of tests on the insulation strength of these materials before and after purification and showed that by simply washing both the silk and the cotton, the insulation resistance increased tremendously. Another paper presented at this session was on the uses of radio as an aid to air navigation. This paper was presented by J. H. Dellinger, chief of the radio section, U. S. Bureau of Standards. The use of radio for guiding airplanes along fixed air routes during fog, or other conditions, in low visibility, was the principal topic of this paper.

At the session for electrical machinery, a paper by F. T. Hague, G. W. Tenney, on the influence of temperature on large commutator operation, was of particular interest. In this paper, it was pointed out that many cases of blackened and burned bars are caused initially by a slight roughness which causes irregular commutation and a slight sparking, which, when once started, gradually becomes worse. The requirements of the surface of a high speed commutator were discussed, showing that radial variation of the order of one ten thousandth of an inch between the commutator bars may give serious trouble. Causes of roughness were discussed showing that temperature is a major factor.

Electrical Measurements of Non-Electrical Quantities

An entire session was devoted to the general subject of electrical measurement of non-electrical quantities. This session included five papers; one on magnetic analysis of material, one on measurement of flow by use of electrical instruments, another the use of the oscillograph for measuring non-electrical quantities, a fourth the study of noises in electrical apparatus, and finally, a paper on electrical aids to navigation. The paper by Spooner and Foltz was a study of noises in electrical apparatus and was of particular interest. The objections to unnecessary noises in electrical apparatus have become so insistent that the manufacturers are making every effort to reduce it. In order to attack the problem intelligently, it is first necessary to determine the amplitude and frequency of the components of complex sound. The first requirement, then, is a simple, portable sound analyzer. In this paper, description was given of two resonant types of instruments which have been developed. There was also included a short discussion of the laws of sound variation and sound units. Finally various applications of the sound analyzer to the study of noises in gears, motors, generators, induction regulators, loud speakers, vacuum cleaners and the like were discussed.

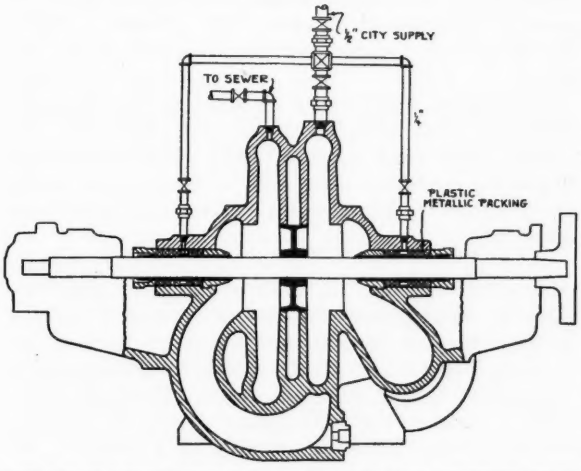
Instruments and Measurements

The convention closed on Friday afternoon with a session on Instruments and Measurements, at which five papers were presented: one on telemetering, another on totalizing of electric system loads, a third on a new high accuracy current transformer, a fourth, 132-kv. shielded potentiometer for determining the accuracy of potential transformers and a fifth, a describing precision regulator for alternating-current voltage.

According to a recent statement by John L. O'Toole, vice-president in charge of public relations with Public Service Electric & Gas Co., Newark, N. J., that organization has recently purchased a tract of some 125 acres of land on Arthur Kill, just north of Sewaren, planned for the erection of one of the world's largest power stations some time in the near future. The proposed power station is the latest development in the company's policy of expansion. When completed, the Sewaren unit will feed the rapidly expanding industrial section of Central New Jersey and will also form a part of the interconnected system comprising Public Service, the Philadelphia Electric Co. and the Pennsylvania Light & Power Co.

Centrifugal Pump Handles Hot Water Successfully

DIFFICULTIES IN HANDLING very hot water may be overcome by sealing the packing glands with cold water, which also lowers the bearing temperatures about 25



USE OF PLASTIC METALLIC PACKING AND PROPER PIPE CONNECTIONS PROVIDES FOR PUMPING OF HOT WATER BY CENTRIFUGAL PUMP

deg., and attaching a ½-in. city supply line to be used in case the pump loses its suction through being steam bound or otherwise.

Piping is not extended above the top of the pump as shown in the illustration but comes up in back of the pump between the suction and discharge pipes. It was indicated above, the better to show the connections. The ¼-in. piping to the seal rings in packing glands helps to lubricate the packing, seals suction against air entering and also cools the shaft. The glands are adjusted for a slight leakage which allows cold water to pass between shaft and packing. The ½-in. pipe connection to the first stage is used when the pump becomes steam bound or loses its suction.

By opening the ½-in. valve and the ¼-in. valve to the pump, any steam or air is driven out of it. With discharge from pump closed and the pump running slowly, the suction is established quickly. The ½-in. valve is then closed and, after the pump has run awhile, the ¼-in. valve is closed again. With this connection, the pump can be put into operation in two minutes, whereas it formerly required several minutes or necessitated starting a stand-by pump. When necessary to take off the pump cover, the piping can be removed by breaking the four unions.

Another difficult problem is packing for the pump shafts. I have solved this by using plastic metallic packing as shown. This packing consists of fine lead wire in short lengths, long-fiber asbestos and graphite. It does not score the bronze protecting sleeve on the shaft and has a long life. I have used this packing for over a year before renewing, with little adjustment of packing glands required.

Tacoma, Wash. EDW. A. HANSEN.

Relation Between M. E. P. and Engine Speed

MR. SHEEHAN'S ARTICLE on page 196 of the February 1 issue is interesting. I would like to comment on the second examination question to which Mr. Sheehan refers, not with regard to the presentation of the article, but solely with the question itself in the abstract. Possibly what I am going to say may not be in agreement with the ideas of some of the readers and if that is so, then profitable discussion may follow the appearance of this letter.

First of all, it has been said by many persons that the question and answer method of imparting information is not good. If this is true, then by the same token the question and answer method is not any good to discover just how much or how little a candidate really knows about any given subject. Further, I may say that in some instances, the questions asked candidates at examinations reveal how little the examiner himself really knows about the subject. Questions are not always worded in such a way that the candidate can give a satisfactory answer, although he may know his subject very well. There is really as much skill required to propound a question as there is to satisfactorily answer it. So it may happen the examiner is just as incompetent as the candidate he fails. I am not holding any brief for the really incompetent man who is trying to obtain a license by "hook or by crook," but I wish to defend the fellow who knows his business but is not expert in the use of pen and ink answers nor in making accurate verbal statements when trying to answer an improperly worded question. Personally, I think questions and answers are O. K. when properly and intelligently used and applied.

Suppose we review briefly that second question referred to in Mr. Sheehan's letter: "How would you secure an earlier cut-off on a Corliss condensing engine when the steam pressure cannot be raised?". With a given mean effective pressure, piston speed and load, cutoff will occur at a certain part of the stroke of the piston and assuming that the valves are correctly set and adjusted, the point of cutoff cannot be reduced unless the load decreases or the piston speed be increased. Considering a simple cylinder condensing Corliss engine as an example, with releasing valve gear and flyball governor, the cutoff is automatically controlled by load fluctuations. The horsepower formula P L A N ÷ 33,000 may be brought into play as follows: We know that for any given engine the numerical values of L and A are fixed, cannot be changed; likewise the 33,000 factor is constant and for my present purpose may be ignored.

Let us suppose that for a given engine the numerical values of P L A N are as follows: $50 \times 3 \times 200 \times (2 \times 60)$, which means that the m.e.p. is 50 lb. per sq. in., the stroke of the piston 3 ft., the area of the piston is 200 sq. in. and the r.p.m. is 60 or 120 strokes per min. because the engine is double acting. Now the product of those numbers equals 3,600,000, which for our purpose may represent the horsepower or load on the engine. If an earlier cutoff were desired, this would mean a lower m.e.p. than 50 lb. and the only way that can be accomplished, the load remaining constant, would be to increase the number of revolutions per minute. This may be accomplished by adding weight to the governor, the equivalent of central weight; not increasing the weight of the flyball as may be thought. Then suppose the r.p.m. be increased to 70 r.p.m. or $2 \times 70 =$ 140 strokes of the piston per min. as against the 120 strokes as first assumed.

The new statement would appear as follows: $X \times 3 \times 200 \times (2 \times 70) = 3{,}600{,}000$ and we want to find the value of X which represents the new m.e.p. required for the increased speed. We divide the 3,600,000 by the product of $3 \times 200 \times 140$ which is 84,000 and obtain as the quotient 42,857; or we can find it by the rule of simple proportion: 140; 120 :: 50: 42,857; so, the new m.e.p. becomes 42 plus, say roughly, 43 lb. This lesser m.e.p. means an earlier cutoff of steam in the cylinder; but for any unit of time a greater quantity of steam will be consumed in order to carry the same load with the engine running at a higher speed, because of the greater number of piston stokes per minute and greater condensation loss due to earlier cutoff.

Now let the "boys" come back and tear the foregoing to pieces if they care to do so. In any case it would be interesting and instructive to hear the ideas of some of the other readers of the paper on the subject.

Brooklyn, N. Y. CHARLES J. MASON.

Outside Storage of Coal

THE INQUIRY OF H. E. M., on page 586 of the May 15 issue, brings up a question which will probably never be settled to the satisfaction of engineers, scientists and coal miners because of the difficulty, in fact impossibility, of obtaining true samples.

For the engineer, the only reliable way is to try storing some of the coal in which he is interested and keep a careful record of his boiler operation, using the stored and unstored coal for comparison. Of course all boiler room conditions must be carefully considered in arriving at results.

Below are a few values that I have copied in my notebook, they are from a Bureau of Mines bulletin of several years ago. As I remember it, the values are the average of several tests which did not agree any too well.

New River Coal (5 years storage)
(determination in per cent)

Location	Storage: Indoors	Outdoors	Submerged	Approx. Av. Temp.
Portsmouth	1.2	1.35	0.4 salt	50
Pittsburg	1.15	1.25	0.28 fresh	55
Norfolk	1.0	1.2	0.5 salt	60
Key West	0.8	2.55 (3 yr.)	0.4 salt (4 yr.)	75

Pittsburg Coal (5 years Storage)

Ann Arbor	0.7

Pocahontas (2 years Storage)

Panama	0.81

Wyoming (2¾ years Storage)

Sheridan	3.19 open bins	4.5 closed bins.

There is a noticeable difference between air and water storage but hardly enough to warrant the expense of this latter type storage except perhaps in such a location as Key West and for long periods. It is questionable how much weight can be placed on the outdoor figures as there is so little agreement between the figures for different localities for underwater storage.

The same thing might be said for the Pittsburgh and Pocahontas coals but the Wyoming coal tests show values which reach a point where underwater storage might be desirable. About 70 or 80 per cent of the deterioration in this coal takes place in the first nine months.

This data covers natural deterioration without undue or excessive heating. In badly stored piles, where temperatures are high and fires frequent, there is of course an excessive loss because of this slow combustion.

I think that it is generally admitted that spontaneous combustion is the important factor of storage and if coal is stored so that this danger is eliminated the deterioration for practical purposes is negligible. The foundation of the pile, the depth, segregation of fines and firmness are all important. If the ground is dry, no weeds or sticks mixed with the coal, the pile is not too deep, it is carefully packed with a scraper, roller or weight and a new pile is not started on an old one, there is little danger. It is well to store the coal in layers about 2 ft. deep; two or three such layers are deep enough for most midwestern coals.

A layer of slack forms on the outside of the pile and tends to protect the inside. Some persons claim that free circulation of air will reduce the danger of spontaneous combustion by cooling the coal, while others say that all possible air should be excluded. Personally I favor the latter view. If air circulation is necessary for cooling, it is certain that oxidation and deterioration are going on, while if air is excluded both possibilities are reduced. Of course the pile must be thin enough so that the heat which is generated will be carried away through the ground and air.

Deterioration of properly stored coal is a bugbear which should not worry the engineer provided he can keep his storage clean, not too deep and avoid excessive temperatures. At least I have never been able to detect any difference through comparative tests of green and stored coal.

St. Petersburg, Fla. PAUL F. ROGERS.

Peculiar Treatment Makes Bearing Run Cool

SOME ENGINEERS BELIEVE that a properly run bearing lining, using heavy bearing babbit metal, does not require a scraping fit; that the shaft can be set into the bearing just as it is run and that it will not heat when running.

This subject reminds me of a bearing treatment that will interest many. The crankpin on a fairly large engine persisted in heating although a good grade of oil was used and the appearance of the pin and bearing was all that should be desired. An assistant in the plant, who was an ex-locomotive engineer, stated that he could fix the pin so that it would run cool.

That evening, after the engine was shut down, the rod was disconnected from the pin and, using a small peening hammer, the pin was peened slightly over its entire surface. This unusual treatment was then completed by using a very fine file over the peened surface. Although the chief had considerable faith in his assistant's ability, he feared that he had made a mistake in permitting the peening; however, the damage, if any, was done, so the rod was replaced and the engine started again. The pin and bearing now ran cool and continued to do so.

I heard of another man who claimed to have used this—what most engineers would claim to be a wrong treatment—only, instead of using a file on the peened surface, he used a long strip of emery cloth giving it a turn around the pin and holding an end of the strip in each hand as he pulled it back and forth. This man used extraordinary care to prevent any grain of emery or metal to remain on the surface of the pin or to get into the bearing. I have not tried the method myself but I have no reason for doubting my informants, both of whom claimed success.

Toronto, Canada. JAMES E. NOBLE.

"I Made It Myself"

MOST OF US ENJOY inventing and making things. We like to "putter around." We like to point at a good-looking device and say, "I made it myself." As a matter of business, however, it is possible to carry the made-it-myself habit too far. Many men do this.

A number of years ago, a good friend of mine made his own automobile; that is, he bought parts here and there, put them together and thought he had a better car than anybody else. But it cost much more than a standard car would have cost and I am sure it was no better than many standard cars that were then on the market.

Not long ago, I was much amused by a well-meaning engineer who had made his own feedwater regulator. He called it "automatic" but in reality it was hardly semi-automatic. It was absolutely undependable and had to be nursed as carefully as is necessary when boilers are equipped with no regulator at all. He "thought" he had saved the owner a couple of hundred dollars but, as a matter of fact, the time required to make the device and the material used in making it were an absolute loss to the owner. Nothing was gained by using the device. It would have been less expensive and better all around had the engineer put in a requisition for a REAL feedwater regulator, installed it and the feedwater problem would have been off his mind. He could then use his time to better advantage elsewhere.

There are few things today, if any at all, that are better when "home-made" than when made by a manufacturer who is tooled to do the work quickly, inexpensively and well. Feed regulators, oiling devices, pressure regulators, damper regulators, paints, gaskets, boiler baffles, boiler compounds, belt dressings, etc.—it is better to leave the making of such things in the hands of the manufacturers who specialize in them.

Newark, N. J. W. F. SCHAPHORST.

Sprinkler Made of Old Pipe Fittings

HOME-MADE WATER HOSE sprinklers for the plant or shop are put together in a good many different ways, and often rigged up out of an endless assortment of odds

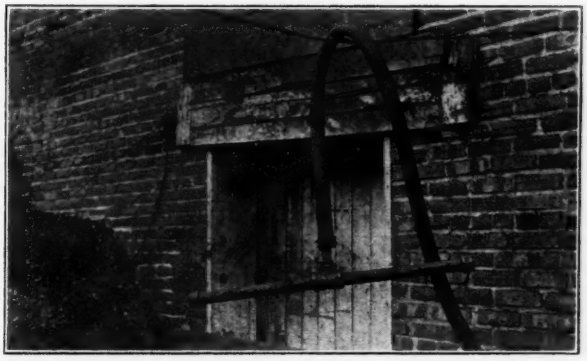


FIG. 1. OLD PIPE FITTINGS MAKE UP HANDY SPRINKLING DEVICE FOR BOILER ROOM USE

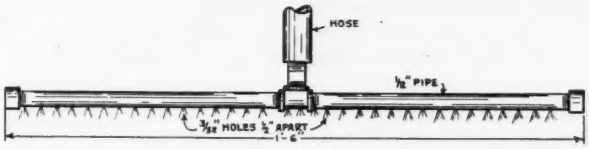


FIG. 2. DETAILS OF SPRINKLER MADE OF PIPE FITTINGS

and ends. The illustration shows a practical and easily made sprinkler constructed of old pipe fittings, the nipples to each side of the center T being drilled with a row of 3/32-in. holes about ⅜-in. apart. Old pipe fittings and odd lengths are easy to get and a sprinkler of ½-in. pipe can and will stand a great deal of hard, rough usage.

Missouri Valley, Iowa. FRANK W. BENTLEY, JR.

Oil Mixed With Clay Prevents Explosion

IN BABBITING A BEARING, the usual procedure is to make a form of thin boards or pasteboard and place it around the shaft or mandrel and stop up the joints or small cracks with clay or fireclay mixed with water.

If engine oil or an oil of equal body is used for mixing the clay instead of water, the babbit will not explode or blow out as it frequently does when water is used. Also, the clay will not dry out and become hard but, on the other hand, actually becomes easier to manipulate the more it is worked.

Portland, Ore. E. POTTER LOCKWOOD.

Questions and Answers

Stack Computation

STATE A FORMULA for computing the diameter and height of a smoke stack: J. D. H.

A. There are a number of approximate formulas for the diameter of stacks, such as follows:

$$D = 0.39 \sqrt{hp^2}$$

in which D is the diameter of the stack in feet and hp is the horsepower of the boiler.

Stack diameter is dependent upon the capacity requirements while height is dependent upon the draft requirements. For the latter, it is necessary to know the draft required to overcome the various resistances to the flow of the gases throughout the entire boiler plant, including the stack. These resistances involve the resistance through the fuel bed, the boiler, the breeching, the turns and bends, the velocity of flow and the flow friction which involves the condition of the inner surface.

If the theoretical amount of draft is known, the theoretical height of a stack can be determined by use of the following equation.

$$H = (D_t) \div 7.63 \left[(1 \div T_o) - (1 \div T_c)\right]$$

where H = theoretical height in ft.

D_t = theoretical draft in inches of water

T_o = Absolute temperature of outside air in deg. F.

T_c = Absolute temperature of stack gases in deg. F.

In this formula, the chimney gas density is assumed to be 0.08071 lb. per cu. ft. at 32 deg. F. and standard atmospheric pressure.

If the theoretical draft is not known, it may be obtained by adding together the various resistances as

$$D_t = h_F + h_B + h_{BR} + h_T + h_D + h_O + h_E + h_V + h_f$$

where h_F = loss of draft in inches of water through fuel bed

h_B = loss of draft in inches of water through boiler

h_{BR} = loss of draft in inches of water through breeching

h_O = loss of draft in inches of water due to turns

h_O = loss of draft in inches of water due to damper friction

h_O = loss of draft in inches of water due to sudden enlargement of an opening

h_E = loss of draft in inches of water through economizer

h_V = loss of draft in inches of water due to velocity of gases

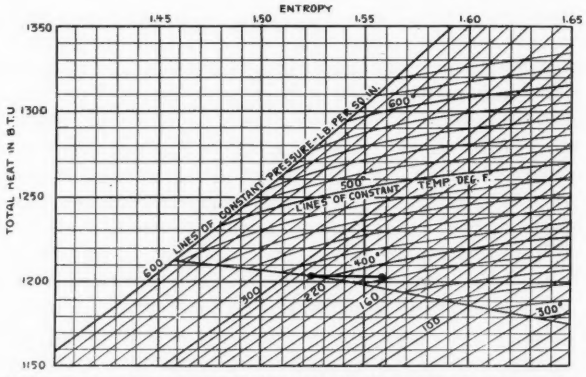
h_f = loss of draft in inches of water through friction

In most engineers' hand books as well as in Mingle's book, charts or tables give heights of stacks under different conditions.

Approximate formulas are not reliable guides for stack design and should not be used unless the design is checked by a more thorough analysis and computation such as is presented in Mingle's book on Draft and Capacity of Chimneys, published by D. Van Nostrand Co., New York City, from which much of the foregoing is taken.

Predetermining Temperature of Reduced Pressure Steam

AT PRESENT, I am operating a 600-hp. water-tube boiler carrying 170 lb. gage pressure, the steam being used for drying veneer in a plywood factory. We have



PORTION OF HEAT ENTROPY DIAGRAM USED IN SOLVING STEAM TEMPERATURE PROBLEM

two dryers and the steam at 170 lb. pressure is circulated through the heating coils. The temperature in one of the dryers is from 280 and 300 deg. F.; on the other dryer the temperature is about 250 to 260 deg. F. The steam is carried about 1000 ft. through well insulated piping.

Another boiler is now being installed. This boiler, however, will be operated at 250 lb. gage pressure and the pressure will be reduced by means of a reducing valve to 170 lb. and delivered to the dryers through the same piping system. Will the temperature of the steam from the 250-lb. boiler reduced to 170 lb. pressure be 50 deg. higher than that from the 170-lb. boilers?

G. C. D.

A. To solve this problem, the most practical method is to use a heat-entropy diagram for steam. Locating the point at which the 265 lb. abs. (250 lb. gage) pressure line crosses the saturation curve, we find that the total heat under these conditions is 1202.3 B.t.u. and the temperature 406.2 deg. F. As this steam expands through the reducing valve isothermally (that

is, without changing the quantity of heat per pound), we trace horizontally to the right to the 185 lb. abs. (170 lb. gage) pressure line and at this point we find that the temperature is 383.4 deg. F. As saturated steam at 170 lb. gage has a temperature of 375.4 deg. F., the increase in temperature would be only 8 deg.

Probably the most economical method of increasing the temperature of your dryers, under your conditions, would be to provide more radiating surface in your dryers, by this means more steam would be condensed and thus more heat delivered to the dryers.

Boiler Operation

How high above the top row of flues should the first gage cock on a horizontal return tube boiler be placed?

2. Why should no scattered coal be allowed to burn on the dead plate of a boiler?

3. What precaution should the fireman take while the engine is being shut down? B. N. M.

A. Each boiler should have at least one water gage glass with connections not less than ½-in. pipe size. The lowest visible part of the water glass shall be not less than 2 in. above the lowest permissible water level. The water gage glass shall be equipped with a valved drain. The lowest permissible water level should be that at which there will be no danger of overheating any part of the boiler when it is operated with the water not lower than that level.

Each boiler should have three or more gage cocks located within the range of the visible length of the water glass except when such boiler has two water glasses with independent connections to the boiler and located on the same horizontal line and not less than 2 ft. apart.

2. No great quantity of scattered coal should be allowed to burn on the dead plate of a boiler because, since no air passes up through this coal as is the case when burning on the grate, it is apt to overheat and perhaps warp and even crack the dead plate. A small amount would do no harm, as it would simply distill off the volatile gases and change to coke and would be pushed into the fire where the solid coke would be burned when the furnace was stoked again.

3. A fireman should check his fires while the engine is being shut down, if only one engine is being served.

Problems Encountered by Boiler Operator

If you find that your boiler shows an inch of oil in the gage glass, what would you do before blowing the boiler down?

2. Name the most common causes of clinker.

3. Explain the entire process of combustion as developed in making a coal fire.

4. What is the first essential of a combustion chamber?

5. Explain the removal of scale from water-tube boilers. W. J. S.

A. If an inch of oil appeared in your gage glass, the best thing to do would be to use the surface blowoff in the boiler.

2. The higher the percentage of iron pyrites, the more likelihood is there of clinkering. Iron pyrites is the form in which sulphur is usually found in coal. This fuses with the ash present in the coal and forms clinker. As the fusing points of irons range from 1922 deg. F. to 2786 deg. F. and that of silicon, one of the principal constituents of ash is 2588 deg. F., high temperatures in the fuel bed will increase clinkering. For this reason, water cooled walls and steam injection are often used.

Improper slicing or stirring of the fuel bed increases the tendency to clinker, for if the bed of ash is raised up and brought into the hottest part of the furnace it is almost sure to fuse into clinker.

3. In the process of combustion of coal, the coal is first heated by burning of other lighter fuel or coal which has been ignited; distillation of the volatile gases then takes place; burning of those gases above the fuel bed follows; and finally, the coke on the grate is burned. If the fuel bed is too thick, producer action may take place. In this case, burning in the lower part of the fuel bed is first to CO_2 and this gas passing up through the thick bed of fuel takes up another atom of C, forming two molecules of CO. To burn this CO to CO_2 requires the admission of air over the fuel bed.

4. The first essential of a combustion chamber is to burn the gases, which have been distilled from the coal on the grate by maintaining the temperature above the point of ignition of the gases and mixing them thoroughly with air.

5. Boiler tube scale may be removed in various ways, depending upon the nature of the scale: It may be removed by cutting or grinding it out by means of special tube cleaners or it may be vibrated loose from the tubes by other special tools, or it may be removed by special chemical processes.

Pump Size and Condenser Action

May I receive some help on the following questions:

1. What ratio of displacement of a condensate pump with a surface condenser to the quantity of condensed steam is the proper one to use?

2. Why are vacuum readings referred to a 30-in. barometer?

3. Explain how hotter condensate may be attained in a surface condenser with a duel bank system.

C. E. D.

A. Ratio of condensate pump capacity to quantity of condensed steam coming from an engine or turbine is usually stated as follows: The capacity of the condensate pump should be twice that of the quantity of condensed steam coming from an engine or turbine under maximum load.

2. Vacuum readings are usually referred to a 30-in. barometer in order to have a definite basis of comparison. By this means, work done at high altitudes or in positions much below sea level may be properly accounted for.

3. When a surface condenser has a dual or double bank system, steam admitted between the banks passes down to the lower part of the condenser where it mixes with condensed steam which has dripped from the cooling tubes of the banks, thus acting, at this point, much like a jet condenser and increasing the condensing effect and raising the temperature of the condensate.

Editorial Comment

That Elusive Income

Low wages or insufficient income is a universal complaint and although the phraseology may differ with the various crafts and professions, the same theme runs through them all.

Insufficient knowledge of other professions and industries is usually at least a contributing cause. The banker's public hours are from 10 to 2 or 3, the lawyer is in court but a few hours a day, the doctor is in his office two or three hours a day, the successful salesman travels all over the country, lives well and has a good time, and so on down the line.

Each person knows intimately the hard work, extra hours, trials and tribulations of his own, but sees only the public life of his neighbor. The banker has his day's work to do after closing time; the lawyer presents at court in minutes what took hours of study or research to prepare; the doctor spends hours at the hospital making calls, and the salesman has his proposals to prepare and his prospect to entertain during his supposedly off hours, so that he can present his proposition during business hours.

The head of one of the finest engineering organizations in the country has a reputation for doing little beyond holding down his chair and keeping a close rein on his organization. He always has free time during office hours, is seldom in bad humor, treats all callers courteously and apparently does little or no work. There are many that wonder, but few that see him go home each night with a fat bundle of papers and still fewer who know that he put in from four to six hours each night on those same papers. His success has been quite phenomenal and yet there are those who know he has earned it by hard work.

One of the most progressive power plant equipment sales organizations in the country netted last year less than a consulting engineer who has an extremely modest business. He lives a busy, apparently prosperous life, yet he has no time of his own, day or night, and has the added responsibility of a large organization.

Taken all in all, most industries and professions pay about the same wage per hour for similar services. Naturally some professions offer better opportunities for investment and profit making from outside sources but these opportunities are more or less open to all those with the inclination, ability or luck to try them, regardless of their connections.

In general, the capable leaders of industry would have been leaders regardless of the profession they had chosen. Unfortunately, this cannot be said of many of those who come just under this classification; many of them are capable men, who achieved their rank and position through ability and hard work, but many were fortunate enough to be in the right place at the opportune time and, although possessing no outstanding qualities, are nevertheless capable of holding on when the rope thrown in their lap had a knot tied in the end.

Perhaps some day our friends who dabble in psychology will be able to hitch a little "occupation meter" on each youngster about the time he starts to school, look ahead twenty years, see what hole he will best fit in and start him on the right path.

Until that time, our present hit-or-miss method will have to suffice. After all, the opportunities in any line are about equal, and nothing but luck will make it possible for the vast majority to be at the right place at the right time. The outstanding minority will be leaders in any field they try.

Most college authorities, of course, favor enrollment limitations of some kind, but when one of their number who is an outstanding figure in both the teaching and engineering professions spends two years on a graduate research student only to have him become a shoe clerk, it is well to assume that their methods of selection and classification are not yet infallible and that Lady Luck is still supreme.

Something New Under the Sun

No development discussed at the recent winter convention of the American Institute of Electrical Engineers in New York created quite as much interest as that of the Deion circuit breaker. Its remarkable simplicity both as to construction and principle of operation as well as its great possibilities of application commanded the attention of every engineer present.

In these columns, we have repeatedly pointed out the need for a new solution to the circuit breaker problem. The modern oil circuit breaker, while highly developed and effective in its performance has certain inherent limitations which it appears no refinement of design is able to correct. Considering the principle upon which it operates, the oil circuit breaker is a marvelous piece of equipment and manufacturers have been tireless in their efforts to perfect it. But, after all, it was devised originally as the most obvious means of overcoming a situation which required immediate solution. It was found that electric circuits could not be interrupted in air without creating destructive arcs, so a suggestion was to immerse the contacts in oil.

Despite the fact that this was a logical suggestion and that for small powers it was effective, the oil circuit breaker of today has certain shortcomings. This statement is made with no intention of criticizing the manufacturer's efforts, since the shortcomings of the modern circuit breaker are not to be found in improper construction but in the principle upon which it operates. In an editorial which appeared on this page over two years ago,* we discussed this matter at length and stressed the need for a new solution to the circuit breaker problem.

Now comes Dr. Slepian with the Deion breaker incorporating a novel principle of extinguishing the arc which has never been applied in commercial equipment.

*November 1, 1926 issue, page 1179.

Containing no oil, simple and compact to a high degree, performing under heavy loads with scarcely a semblance of an arc, this breaker seems to possess characteristics which destine it to a great future.

In this breaker, the arc formed by separation of the contacts, is almost instantly deionized by breaking it up into a number of short arcs in series. This is accomplished simply by blowing the arc by means of a magnetic field into a stack of closely spaced metal plates.

No less remarkable than the device itself is the history of its development. It was by no accident that a stack of metal plates was placed above the arc and found to be effective. It was due rather to an admirable piece of scientific research which was based upon the most fundamental theories of electricity. For a period of over five years, Dr. Slepian and his associates conducted a most refined and thorough investigation into arc phenomena and from the information this secured, coupled with a knowledge of modern atomic and electrical theory, the Deion breaker was developed.

Thus, once more, from a consideration of the behavior of such intangible things as electrons and the application of sound judgment, comes an engineering development of highest practical importance to the electrical industry.

Extra! Purchasing Agents Have Ethics

Contrary to the belief of all salesmen and most engineers, purchasing agents have a code of ethics, not only a code of ethics but a brand new code of ten commandments which it gives us pleasure to reproduce:

First.—To buy and sell on the basis of value, recognizing that value represents that combination of quality, service and price which assures greatest ultimate economy to the user.

Second.—To respect our obligations and neither expressly nor impliedly to promise a performance which we cannot reasonably expect to fulfill.

Third.—To avoid misrepresentation and sharp practice in our purchases and sales, recognizing that permanent business relations can be maintained only on a structure of honesty and fair dealing.

Fourth.—To be courteous and considerate to those with whom we deal, to be prompt and businesslike in our appointments, and to carry on negotiations with all reasonable expedition.

Fifth.—To avoid statements tending to injure or discredit a legitimate competitor and to divulge no information acquired in confidence with the intent of giving or receiving an unfair advantage in a competitive business transaction.

Sixth.—To strive for simplification and standardization within the bounds of utility and industrial economy, and to further the development of products and methods which will improve industrial efficiency.

Seventh.—To recognize that character is the greatest asset in commerce and to give it major consideration in the selection of customers and sources of supply.

Eighth.—To adjust claims and settle disputes on the basis of facts and fairness; to submit the facts to arbitration if a mutual agreement cannot be reached.

Ninth.—To provide or accept no gifts or entertainment in the guise of sales expense, where the intent or effect is to unduly prejudice the recipient in favor of the donor as against legitimate competitors.

Tenth.—To give or receive no bribes, in the form of money or otherwise, in any commercial transaction, and to expose commercial bribery wherever encountered for the purpose of maintaining the highest standard of ethics in American industry.

Lest joy be unconfined, however, we must admit that this code has been officially adopted only by the National Association of Purchasing Agents and it would perhaps be well for each salesman henceforth to carry around a membership list of the society so he will know beforehand whether his prospective visitor has ethics or not.

And then the code is more or less reversible, so to speak. Salesmen can live by it as well as for it. Perhaps some day the millennium will come about and a salesman who practices the code will meet a purchasing agent who practices it also and they will be able to convince each other that they practice it. Until that time we must go our separate ways, trying individually to live up to that code and our more extensive code as well.

Interchangeability and Costs

Combinations of various factors during the past two or three years have led some public utilities to install extremely large generating units which have, in effect, been tailor-made for each installation. Factors influencing the selection of such large units include the load conditions of a given system, the higher efficiency and lower fixed charges and operating costs per unit output of such units and, not least in importance, the ability and willingness of the manufacturers to supply them.

In manufacturing such units, the turbine generator manufacturer must of necessity forego, at least for the present, the advantages of standardized design that apply to units of smaller capacity. And in doing this, the manufacturer deserves the highest credit for his willingness to forego these advantages and to supply the large units more for the advancement of the art than for the immediate profit he might receive.

Many cases arise, however, in which the necessity for installing extremely large units in a station, departing from the size and type of units already installed, should be carefully analyzed. Interchangeability of parts of generating units and important auxiliaries has a real dollars and cents value for the operating engineer as well as in reducing development costs for the manufacturers.

Readers of Power Plant Engineering are also doubtless familiar with the arrangements of generating units at the Philo and Twin Branch Stations, where interchangeable parts of the units were kept in storage at each plant for shipment to the other plant if necessary.

It should not be inferred that necessity for interchangeability of parts of units is caused necessarily by faults of the manufacturer or that advantages of the larger units will be counter-balanced by this factor. We may yet see the day when 150,000-kw. units will be standardized in design and will be referred to as small units. In such a case the interchangeability factor will have to be given the most careful consideration in station design just as it should be today.

Masters *of* Power Discuss Progress *of the* Industry at Chicago

Four-day Meeting hears papers on design, construction and economics of power plants and allied subjects

WITH A TOTAL attendance of about 2500 engineers and their guests at the various technical sessions, luncheon, banquet and other meetings, the Fourth Midwest Power Engineering Conference was held at the Palmer House, Chicago, Ill., from Feb. 12 to 15.

After registration on Tuesday and a luncheon addressed by W. L. Abbott, president of the conference, the afternoon session opened at 2:00 p. m., with L. R. Houson presiding, for the discussion of Power Plant Substructure problems.

Power Plant Substructure Problems

H. G. Roby of Byllesby Engineering and Management Corp., delivered a paper on Details of Design and Construction of the Steam Flow Power Plant at Louisville, Ky., as abstracted in the Feb. 15 issue of Power Plant Engineering. This was followed by a paper on Power Plant Substructure Problems by J. C. Sanderson, Sargent & Lundy, Inc., as abstracted in the Feb. 15 issue, discussing four recent steam stations.

P. E. Stevens of Byllesby Engineering & Management Corp. then gave a paper on Design and Construction of Substructures of Steam Power Stations in Various Localities in the United States. He described first the building of the substructure of Hibridge Station in St. Paul. Here the subterranean survey indicated soft silt to a depth of about 19 ft. or approximate low water, with ground water at a depth of about 8 ft. Below this was a 20-ft. stratum of soft clay and sand, with indications of very firm sand beneath. Footings were designed for McArthur pedestal piles to rest on the sand stratum at a depth of about 40 ft. or 20 ft. below low water. The small shallow pits for walls and column footings were excavated by hand in open cut. For the deeper pits, steel sheet piling was driven and the material removed by bucket and derrick. In some areas, a combination wood and concrete pile was used to get the desired bearing value.

Construction Methods at Various Stations

At the Riverbank Station of the Oklahoma Gas & Electric Co., footings under the turbine room columns rest on McArthur pedestal piles and excavation was largely in open cut, steel sheet piling being used only for the deeper pits.

For Waterside Station of the Louisville Gas & Electric Co., the condenser pit and screen well were each constructed above ground as a caisson of reënforced concrete, open at top and bottom, provided with a steel cutting edge and dredged into place.

At the Horseshoe Lake Station of Oklahoma Gas & Electric Co. material was loosened by a stream of water from a pipe nozzle and was then pumped to the surface by a centrifugal pump.

Problems of wet excavation were solved in the pit and tunnel work at the plant of San Diego Consolidated Gas & Electric Co. by excavating a shallow trench, building in it the three longitudinal walls and roof of tunnels and sinking them into position by excavating from the inside under compressed air. The tunnels were surmounted by longitudinal walls to prevent caving from the sides and excavated material was blown out and deposited on the roof of the tunnel, providing the weight necessary for sinking. The soil is a fine sandy clay, hard as brick when dry and quite fluid when wet.

Metallurgical and Chemical Problems

Wednesday morning's session, at which C. C. Whittier presided, was devoted to metallurgical and chemical problems. Professor A. E. White, director of the department of Engineering Research, University of Michigan, read a paper on the metals used in power plants and the tests applied to them to determine their suitability for various services.

Some Aspects of the Corrosion Problem as Applied to Power Plants was the next paper, by H. S. Rawdon, metallurgist, and K. H. Logan, electrical engineer, both of the Bureau of Standards. This paper pointed out that the most serious corrosion problems arise in connection with the generation and utilization of steam, calling attention to the troubles arising from impurities in the water as distinct from the limited corrosion troubles caused by the steam itself. Influence of the character of the metal was next discussed; the paper referred to recently developed corrosion-resisting steel. As a rule, the authors state, the seriousness of any case of corrosion is not primarily caused by the composition of the steel used. The authors stated that "steel, which according to the results of experience should be entirely satisfactory for the purpose, can be made worthless by the 'brutal' treatment which it not infrequently receives in the erection of the installation."

Embrittlement was discussed, as well as corrosion from furnace combustion products. The second part of the paper dealt with corrosion problems outside the plant, such as corrosion of transmission line towers and conductors, also materials used for underground transmission.

Utilization of Power in Chemical Industries

Final paper of the session was on Utilization of Power in Chemical Industries by C. M. A. Stine of E. I. Du Pont de Nemours & Co., Inc. At the noon luncheon meeting held under the auspices of the American Institute of Electrical Engineers, R. F. Schuchardt, president of the institute, presided. G. L. Clark, Professor of Chemistry, University of Illinois, spoke on the indus-

trial uses of x-rays, his paper being abstracted in the Feb. 15 issue of Power Plant Engineering.

Electrical Engineering Session

P. B. Juhnke presided over the Wednesday afternoon session which was devoted to electrical engineering problems. A paper outlining briefly some of the recent tendencies in electric system development was presented by W. F. Sims of the Commonwealth Edison Co. Another on Synchronous Supervisory System and Telemetering was presented by C. E. Stewart of the General Electric Co. and was accompanied by a motion picture film that showed the operation of the system by means of animated diagrams.

The papers invoked little discussion. Mr. Wensley of the Westinghouse Electric & Mfg. Co. took issue with Mr. Stewart on the relative merits of single impulse versus code or automatic impulse control of supervisory systems and discussed briefly the suitability of telephone relay equipment on power systems.

Mr. Wensley's contention was that no circuit breaker should ever be controlled by a single electrical impulse, since such impulses are often induced in circuits by transients on other systems. Mr. Stewart, in replying, stated that, in the systems under consideration, the control wire was open at all times except when the system was actually being used.

Heating, Ventilation and Refrigeration Session

Thursday morning's session, presided over by Professor A. C. Willard, was devoted to heating, ventilating and refrigeration problems. S. C. Bloom, consulting engineer, gave a paper on Refrigeration and Ventilation as Aids to National Efficiency. He showed how demands for cooling of dwellings, office buildings and all industrial structures were leading to development and application of equipment for this service, increasing health, efficiency and comfort.

F. E. Hartman, discussing the paper, commended the economic viewpoint taken by Mr. Bloom and called attention to economies of recirculation and use of ozone in this process. W. L. Abbott said he had come to drop an onion into the omelet. "All the things Mr. Bloom mentions would be possible," he stated, "if they could keep people out of the buildings, but, when it comes to regulating the office boys and particularly the executives to keep their windows shut and their ventilation adjusted as it should be, you will find that there is where the difficulty begins, and such regulation is essential to the proper operation of these systems."

Mr. Bloom, in closing, said that use of high pressure air would help in eliminating inequalities due to the human element mentioned by Mr. Abbott.

Food Supply Depends on Refrigeration

The second paper of the morning, by A. J. Authenrieth, Middle West Utilities Co., discussed Application of Refrigeration to Preservation of Foods, Taking into Consideration Cold Storage, Packing Houses, Transit, and so on. He showed how refrigeration permits various sections of the country to produce food products that can be shipped anywhere, stored if necessary and delivered to the consumer in perfect condition, almost independent of seasons. His figures on products handled by railroad and steamship, and on the refrigeration and ice business as a power consumer, were of interest. The yearly power consumption for all refrigeration in the United States, the author said, was 3,757,263,200 kw-hr.

Professor J. D. Wood, discussing this paper, called attention to the increasing interest in domestic refrigerator units and to the 8 per cent increase in the ice industry in 1928.

Samuel R. Lewis read the third paper of the morning on Research as Applied to Heating and Ventilating. This paper discussed some of the important problems in this field on which work is now being done and described the various activities leading to their solution that are being carried on by many agencies, such as the A. S. H. & V. E., the Bureau of Mines and several of the universities of the country, all coöperating. For two years, Mr. Lewis has been chairman of the committee on Research of the American Society of Heating and Ventilating engineers.

At the Thursday noon luncheon, under the auspices of the Western Society of Engineers, John A. Garcia presided and R. C. Allen of Westinghouse Electric & Mfg. Co. addressed the meeting on recent developments in turbine design.

Power Plant Operation Session

Thursday afternoon's session opened, with Julius L. Hecht as chairman, for the discussion of Power Plant Operation. P. J. Gaudy of Sessions Engineering Co. read a paper on Coördination of Industrial Plant and Central Station Power. The next paper on Centrifugal Pump Economics, by Professor A. F. Scherzer of the University of Michigan, was abstracted in our Feb. 15 issue.

Discussing Professor Scherzer's paper, H. C. Heaton of Sargent & Lundy, Inc., stated that his principal criticism of centrifugal pump design was criticism of mechanical design rather than of theoretical or actual pumping efficiency. This was especially true, he said, with respect to high-speed, high-pressure pumps such as those used for boiler feeding. He recommended particular attention to making shafts heavy enough, clearances right, provision for expansion, and framework and casing sufficiently stiff to prevent warping. In short, he recommended complete coöperation between hydraulic, designing, mechanical and operating engineers with regard to such pumps.

Power Plant Piping

Welding of Power Plant Piping was the final paper of the session, presented by Fred G. Outcault, of Linde Air Products. He stated that use of welded pipe results in economy in design and material, joints, elbows and bends of the same strength as the pipe, simplification of erection problems, economy of insulation and low maintenance if the welding is done under procedure control. He outlined such a procedure control, reported results of tests by National Tube Co. showing that a properly made oxy-acetylene-welded joint is as strong as the pipe and that the simple butt-welded joint is the most efficient and then showed interesting slides illustrating various types of welded joints. He gave data on methods of testing and inspecting welds.

F. W. Martin, of Sargent & Lundy, Inc., discussing the paper, stated that his company has used forge and hammer welded steam separators for 600 lb. pressure with unqualified success. On some high-pressure lines, however, such as boiler feed lines, joints such as the Sarlun are used, because, for such service, it is difficult, he stated, to determine the success of welds in commercial practice and the joints are often inaccessible for welding. Because of present inability to determine accurately in the field the difference between good and bad welds, Mr. Martin said that his company felt it advisable to continue the use of the Sarlun joint until dependable methods of field inspection now being investigated, are assured. Electrical methods developed by Elmer A. Sperry, also x-ray examination, might prove useful in inspecting welds, Mr. Martin said. Mr. Throckmorton asked Mr. Outcault about annealing of welds and the latter replied that since tests showed 100 per cent efficiency of butt-welded joints without annealing, it did not seem necessary. Mr. Outcault further stated in reply to Mr. Martin, that accessibility for welding is possible wherever the joint is accessible for bolt tightening and that inspection is no more difficult in the field than in the shop.

On Thursday evening, at the annual banquet of the Conference held in the Palmer House, Dr. Walter Dill Scott, president of Northwestern University, addressed a gathering of about 1000 engineers and their guests.

Economics of Power Plants

At the last session or Friday morning, A. A. Potter, Chairman, a paper on 1200-lb. as a Dollar Saver, by Edwin Jowett of Kansas City Power & Light Co., was read by J. A. Keith of that company. This paper was abstracted in some detail on page 257 of the February 15 issue of Power Plant Engineering. In discussing it, M. K. Drewry of the Milwaukee Electric Railway & Light Co. showed slides that demonstrated how closely the results with the 1200-lb. unit at Lakeside agreed with those obtained at Northeast Station. With high-pressure boilers of 10 per cent of the total capacity of the station and high-pressure turbine of 15 per cent of the total generating capacity, making 30 per cent of the station output, there is an increase of 1000 B.t.u. per kw-hr. in the rate when the high-pressure unit is out of service. Both at Lakeside and Northeast the increase in cost was about the same (7.4 and 8.8 per cent respectively) as were the annual net savings of $98,900 at Lakeside and $92,200 at Northeast.

W. B. Saunier of W. S. Barstow & Co. gave data on the Holland Station designed by his company for 1200-lb. operation.

Plant Practice and Engineering Insurance was discussed in a paper by J. P. Morrison of Hartford Steam Boiler Inspection and Insurance Co. He gave details of what can be covered by insurance in the power plant, showed interesting slides of power plant accidents and equipment and discussed some of the causes of these accidents and methods of preventing them.

Stokers for the Modern Boiler Room

The final paper on Modern Stoker Equipment was by Dr. C. F. Hirshfeld, chief of research, Detroit Edison Co., and G. V. Moran, delivered by Dr. Hirshfeld. This paper gave a brief account of the present status of stoker firing with particular reference to the underfeed and chain grate types.

Advance of the stoker has been greatly affected, said Dr. Hirshfeld, by certain outside influences. Increase in size of steam generating units, brought about by increase in size of prime movers, led to development of water-cooled furnace walls. Use of preheated air followed as furnace temperatures took an upward trend owing to the ability of the water-cooled wall to sustain them. These factors opened up greater possibilities for the stoker, which has been adapted to them.

The paper stressed the advisability of being generous when choosing stoker auxiliaries, such as motors and fans, both as to size, capacity and range and refinement of speed adjustment.

Direct-current drive is more flexible but costly, while alternating-current drive, less flexible is also less expensive. When alternating current-drive approaches the flexibility of direct-current it also becomes complicated and almost as expensive. Automatic combustion control, the paper states, cannot excel the results obtained by careful and skilled operators. Such operators, however, are extremely scarce, said Dr. Hirshfeld, and besides that, he does not believe in performing operations by hand that can be done better by machine. Therefore, he does not mean to imply that automatic combustion controls should not be used but that their use should be governed by the type of operators available, costs of fuel and labor, size of units and so on.

He showed many interesting slides, including curves showing progress in dimensions and coal-burning capacities of stokers and views of modern stoker installations.

Six Companies Joined in North American Refractories

Consolidation of six leading companies in the fire brick and refractories manufacturing and selling fields, owning 15 plants in Pennsylvania, Ohio, Kentucky and Missouri, into one organization known as North American Refractories Co., was announced recently. The new company is organized under the laws of Delaware.

The units to be acquired by North American Refractories Co. include Ashland Fire Brick Co. of Ashland, Ky.; Crescent Refractories Co., Curwensville, Pa.; Dover Fire Brick Co., Cleveland, O.; Elk Fire Brick Co., St. Mary's, Pa.; the Farber Fire Brick Co., Farber, Mo., and Queens Run Refractories Co., Inc., Lock Haven, Pa. Capacity of the company's fifteen plants is estimated at 155,000,000 bricks per year.

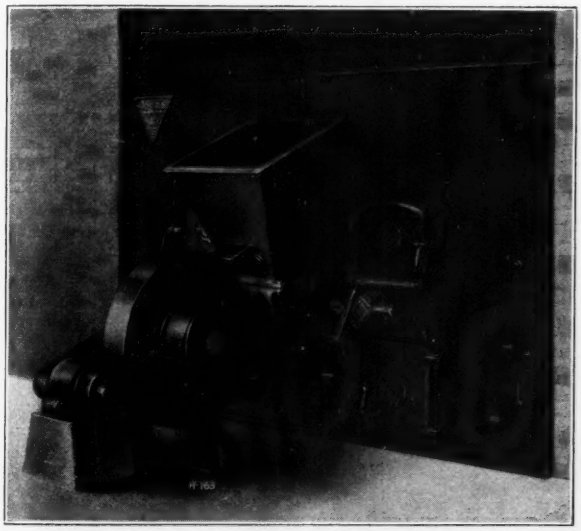
Officers and directors include: president, John D. Ramsey; first vice-president, E. M. Weinfurtner; H. E. Stuhler, J. M. McKinley, E. H. Gartrell, H. A. Sleicher, J. H. Cavender. Directors, in addition to the officers, are: Frank H. Deal, Alfred S. Zopfi, Wm. K. Brownlee, James B. Graham, Wm. G. Bauer, and Henry Lockhart, Jr., and Charles M. Marvin of Blair & Co., Inc.

Board of Education, Hunter College, Park Ave. and 69th St., New York, plans the construction of a new power plant in connection with an expansion program to cost about $750,000. Thompson, Holmes & Convers, 101 Park Ave., are architects; Kaiser, Muller & Davis, same address, are electrical engineers.

Power Plant Engineering Developments and News

Riflex Mechanical Drive for Stokers

RIFLEX mechanical drive, designed especially for Jones stokers as shown, has recently been placed on the market. This drive is intended to give a variable coal feed with a constant speed motor, as well as to



RIFLEX DRIVE ON JONES STOKER

obtain a quick thrust of the plunger so as to give effective slicing action, break up the fuel bed and assure proper mixing of air and fuel.

This is accomplished by a large spur gear which rotates continuously and which operates the crankshaft and plunger intermittently by means of a clutch keyed to the crankshaft. The number of strokes of the plunger per minute or per hour is regulated by a special timing mechanism. This mechanism consists of a train of levers, cams and a trigger, so arranged that a vertical rod is gradually raised until it trips the trigger, causing an arm to force a clutch pin into place, thus engaging the clutch and permitting the crankshaft to make one revolution or one complete plunger stroke. When this is completed, the mechanism withdraws the clutch pin until the vertical rod again actuates the mechanism to force it in again. By simple adjustments made from the outside during operation, the vertical rod motion can be varied so that the clutch pin can be made to engage at any desired interval, thus varying the number of plunger strokes per hour to any desired amount. These adjustments are designed to be so fine that the plunger will make a stroke only every 12 or 15 min., if desired.

It is stated that this mechanism permits coal feed at any desired rate between 60 and 6000 lb. an hour when using a constant speed motor and that fires can be banked in less than three minutes or built up quickly.

Use of a single spur gear reduction, it is further stated, make possible a compact drive, quiet in operation and using only a small amount of power. The Riflex drive is a product of Riley Stoker Corp., Worcester, Mass.

Kennedy-Van Saun Burners

FOR BURNING pulverized coal, three new burners have recently been placed on the market by Kennedy-Van Saun Manufacturing & Engineering Corp., New York. In the vortex burner, Fig. 1, primary air

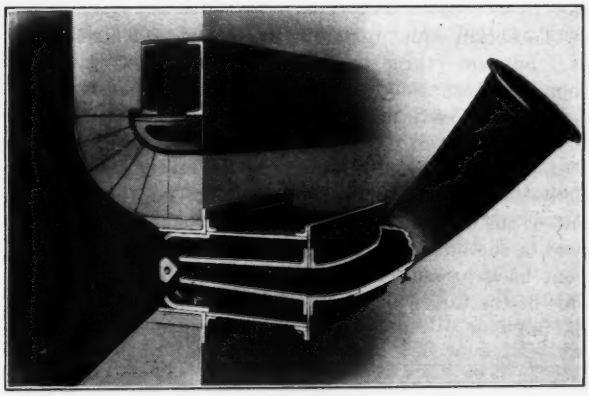


FIG. 1. VORTEX BURNER HAS V-SHAPED DEFLECTOR TO PRODUCE TURBULENCE

and coal are delivered through a rectangular opening, usually horizontal, impinging on a V-shaped deflector the position of which can be adjusted towards or away from the opening. The deflector is intended to split the coal and air stream into two parts; secondary air, delivered at sufficient pressure to drive it into the coal stream, enters from the windbox and passes over the curved deflectors above and below the burner orifices. The object of these arrangements is to produce intense turbulence at the burner tip, giving short flame and good combustion.

As shown in Fig. 2, the duplex burner contains a stream-line-shaped piece in the nozzle to divide the stream of coal and primary air and to give turbulence, while secondary air enters around the entire burner to

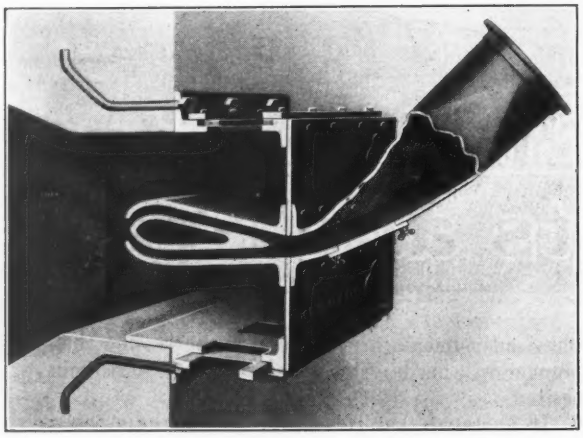


FIG. 2. DUPLEX BURNER FOR NATURAL-DRAFT SECONDARY AIR

mix with the coal and primary air stream. This type of burner is primarily designed for installations where the secondary air is furnished by natural draft.

Figure 3 shows the rotary burner, designed for burning coal, gas or oil and especially designed and recommended for Scotch marine and return tubular boilers. This burner also employs the vortex tip. Primary air and coal are delivered at a tangent and pass through an annular orifice over the vortex tip, the design being intended to cause the stream to leave the tip with a high velocity rotary motion. Secondary air is delivered through the registers in a rotary motion around the coal stream. The design is intended to produce a short, turbulent flame.

To obtain equal distribution of coal and air to several burners (three or more) fed from one mill, the company has also developed a coal distributor. This consists of a conical chamber containing a rotating cone driven by a small motor. This chamber receives all coal and air coming from the primary fan and is designed to deliver it proportionately to openings on the opposite end of the distributor casing; from these openings, pipes lead to the burners. The distributor is designed to prevent back pressure from building up on the discharge side of the fan, which would increase the load and wear on the fan.

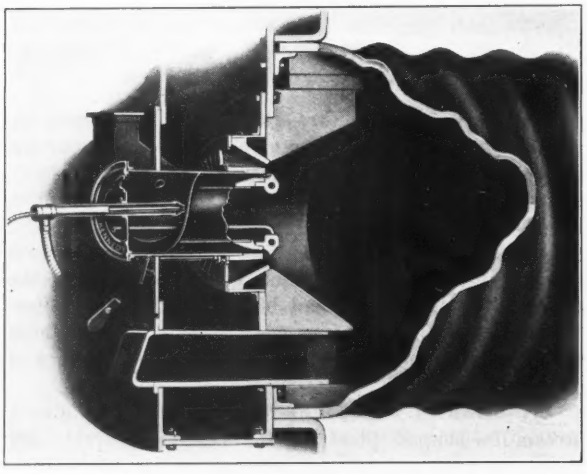


FIG. 3. ROTARY BURNER FOR HIGH TURBULENCE WITH COAL OIL OR GAS

Type G K Diaphragm Meter

TYPE GK DIAPHRAGM flow meter, shown in Fig. 1, has recently been developed by Builders Iron Foundry, Providence, R. I. This meter operates by direct mechanical connection to a diaphragm, which is moved by direct fluid pressure transmitted from an orifice in the line where flow is to be measured. Special rubber diaphragm is used, Fig. 2, restrained by two phosphor bronze springs and partly supported by a conical shield. Pressure on upstream and downsteam sides of the orifice is transmitted through piping as shown and the motion of the diaphragm is transferred through a crank and shaft to an indicator hand. Diaphragm shield is designed so that the motion of the crank is nearly in proportion to the rate of flow over the range of the instrument. The shield is also intended to protect the diaphragm and to prevent change of area as it ages.

An 8-in. circular chart, driven by a heavy-duty Warren Telechron electric clock is used to record the flow, the pen arm being actuated by the crank that moves the indicator. The counter, showing total flow, is operated by a pawl and ratchet; the pawl is driven by the chart clock motor and moves the ratchet a vary-

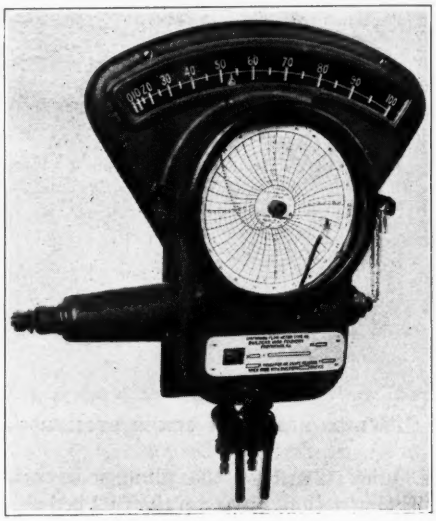


FIG. 1. TYPE GK METER INDICATES, RECORDS AND INTEGRATES FLOW

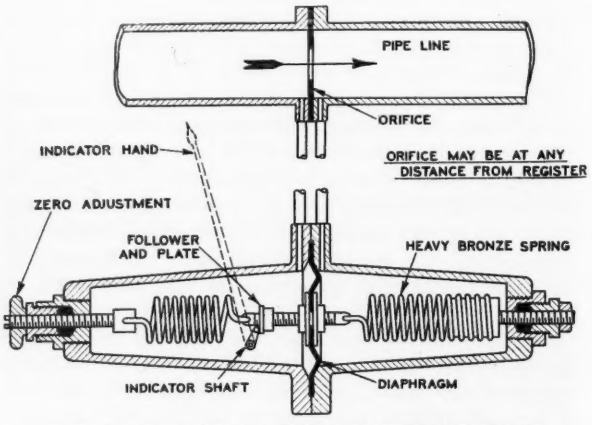


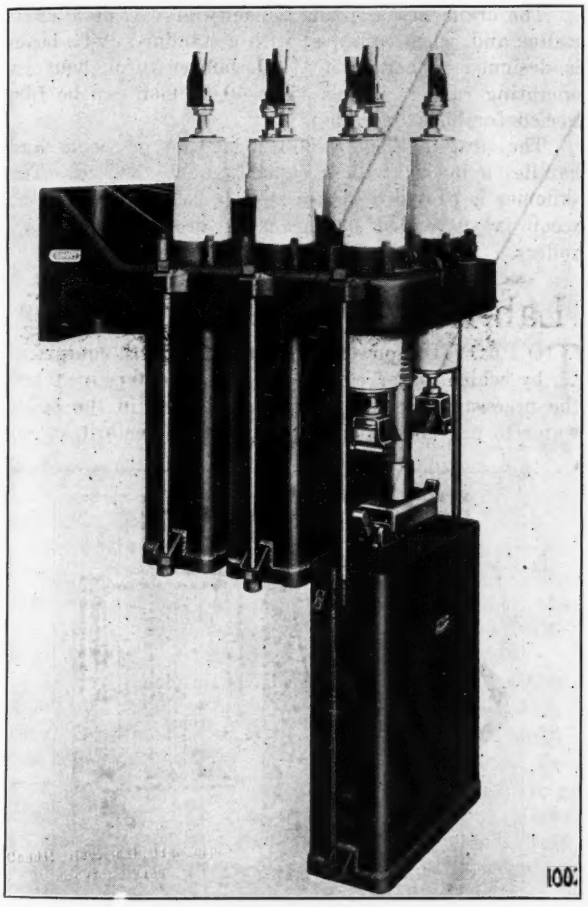
FIG. 2. SECTION THROUGH DIAPHRAGM CASE

ing amount, depending on the position of the chart pen, that is, on the rate of flow.

The meter is designed for mounting on a wall bracket and for use at distances up to 100 ft. from the line being measured. One orifice is usually supplied with the instrument but others of varying capacity can be furnished to be used with one carrier, designed for convenient and rapid installation in the pipe line, to increase the range of the instrument almost without limit.

Circuit Breaker for Moderate Capacities

FOR THE CONTROL and protection of feeders in substations and in industrial service, the Condit Electrical Mfg. Corp. of Boston, Mass., has recently placed on the market the compact oil circuit breaker



CONDIT OIL CIRCUIT BREAKER WITH ONE TANK LOWERED TO SHOW POLE CONSTRUCTION

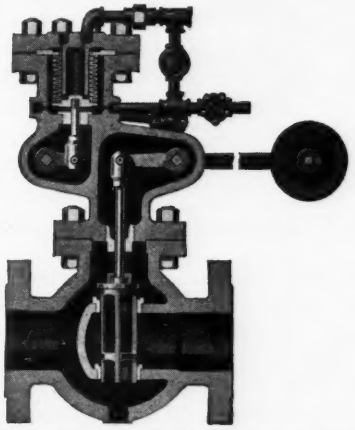
shown in the accompanying illustration. This breaker is known as Type D-123.

Its frame is strongly constructed, with a deep extending web surrounding the tank. Strong tank-per-pole construction is used of thick steel plate scientifically welded. Inverted laminated brushes are of special design to withstand extremely high inrush currents. Exceptionally heavy arcing contacts materially reduce arcing on interruption.

Type D-123 oil circuit breaker is furnished for 400, 600, 800 and 1200 amp. at 15,000 v.; 1600 amp. at 7500 v. Estimated interrupting capacity, 2700 amp. at 15,000 v.

Copes Type DS Pump Governor

FOR INSTALLATION on simplex, duplex or triplex pumps and on turbine or motor driven centrifugal pumps, a new Copes Type DS pump governor has been designed. It is intended for differential excess pressure



SYLPHON BELLOWS ACTUATES PUMP GOVERNOR

service for boiler feeding; constant pressure service; differential reducing valve service on motor-driven centrifugal pumps; relief valve service on belt or gear driven pumps.

The actuating element of the new governor is a two-ply brass sylphon bellows which has been subjected, it is stated, to tests of 93,000,000 reversals without failure. It is designed to be unaffected by high steam or water temperatures and to withstand an unbalanced pressure of more than 400 lb. A horizontal lever shaft, similar to the one used in the control valve of the Copes feedwater regulator, is employed.

This new governor can be furnished by Northern Equipment Co., Erie, Pa., in all sizes with straightway or angle bodies for 250, 400, 600, 900 and 1350 lb. standard. It can be placed in either horizontal or vertical lines.

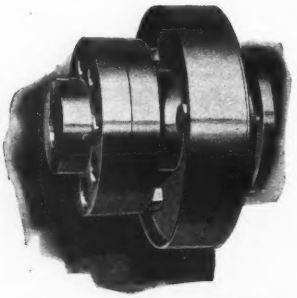
Combination Automatic Backstop and Flexible Coupling

COMBINATION automatic backstop and flexible coupling shown here is designed for use on conveyors and process equipment drives where there is a likelihood of reversal of travel when equipment is standing idle or when the driving motor is shut down after a day's run or for any other reason.

This unit consists of a drum-shaped housing, on the back of which and integral with it, is one-half of a flexible coupling; this coupling contains free-flexing, live-rubber bumpers, in which are cemented oilless bushings. A one-half coupling with hardened and ground steel pins floating inside the graphite-impregnated

bronze bushings, a ratchet plate, three pawls with studs, springs and fastening bolts and a two-piece cover plate complete the unit.

The backstop is applied on the drive shaft between a speed reducer and motor. A flange attached to the speed reducer housing is cast integral with a ratchet which operates in the drum housing; this in turn is connected to the motor shaft through a flexible rubber bumper coupling. On the inner face of the housing



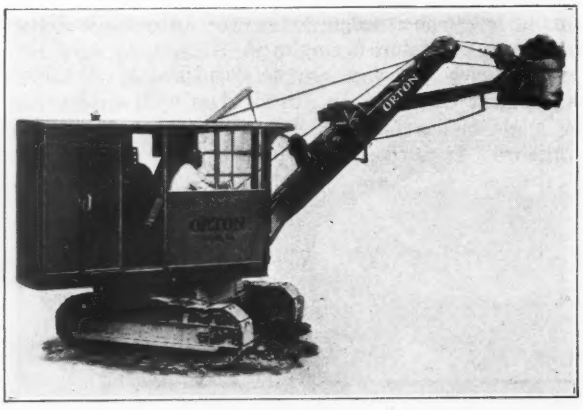
AUTOMATIC BACKSTOP AND FLEXIBLE COUPLING

three pawls are fastened, which engage the ratchet when the housing stops revolving. Centrifugal force keeps the pawls out of engagement during operation but, when the driven unit stops, they fall by their own weight into engagement with the ratchet. This device is a recent product of D. O. James Mfg. Co., Chicago, Ill.

Orton ⅝-Yd. Convertible Shovel

ONE OF THE recent developments in shovel design is the new Model "A" convertible ⅝-yd. shovel recently brought out by the Orton Crane & Shovel Co., Chicago, Ill.

Strength and rigidity of the base are obtained by building it of rolled plates and shapes, thoroughly



ORTON CONVERTIBLE SHOVEL

riveted and electric welded. Structural steel is used to combine lightness with uniformity of material and prevent blowout holes or shrinkage cracks. Electric welding is used to give the necessary rigidity for supporting shafts and bearings and for withstanding operating strains.

Flexible crawling treads of the spring type are designed to absorb shocks and protect the operating mechanism from undue strains. Model "A" can also be furnished with road wheels or for mounting on standard auto-truck chassis.

All of the power shafts are made of alloy steel and are turned and ground. Each power shaft is in a horizontal position and can be removed without interfering with any of the others.

Power is provided by the heavy-duty 53-hp. Hercules motor, which is provided with an electric starter as standard equipment.

Model "A" can be furnished with shovel, crane, dragline, ditcher or skimmer attachment and is designed to be changed from one to any other in the field in less than 2 hr.

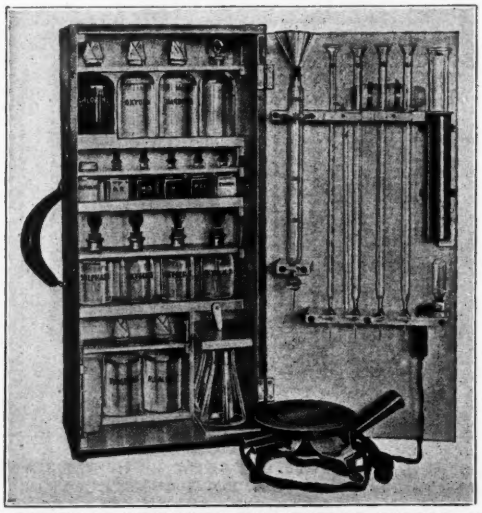
Feature of the shovel is stated to be the positive crowding action, the full power of the engine being transmitted directly to the digging edge of the dipper by the patented gear-driven crowding device.

The crane has a lifting capacity of 6 t. at a 12-ft. radius and, when equipped with a standard 30-ft. boom is designed to handle a ½-yd. bucket throughout its operating range. Booms 35 or 40 ft. long can be furnished for hook operation.

The dragline has a 30-ft., lattice-type boom and handles a bucket with a capacity of ½ cu. yd. The skimmer is provided with a steel boom, from which the scoop is suspended by means of bronze-bushed steel rollers.

Lab-Rette for Water Testing

TO PROVIDE power plant engineers with equipment by which water conditions can be determined and the necessary chemical limits maintained in the boiler water to prevent scale, corrosion, caustic embrittlement



LAB-RETTE IS DESIGNED FOR BOILER WATER AND FEEDWATER ANALYSIS

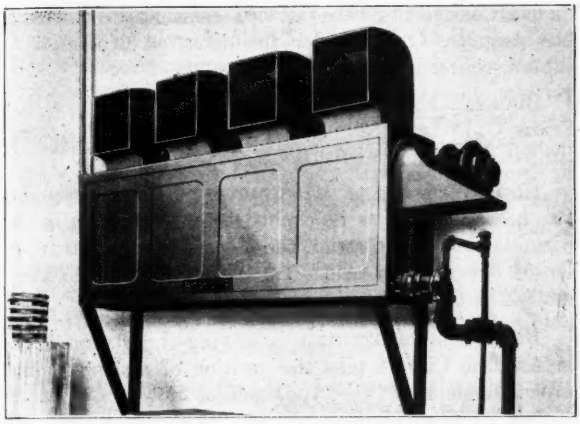
and priming, the Lab-Rette shown herewith has been developed by the Babcock & Wilcox Co., New York City. The Lab-Rette is essentially a small laboratory for making approximate analysis of the feedwater and boiler water and for checking the water conditions that should be maintained by a system of treatment employing sodium phosphate, sodium carbonate and sodium

sulphate. The apparatus is designed to determine hardness, chlorides, sodium phosphate, alkalinity, pH value, sodium sulphate, dissolved oxygen and total dissolved solids.

Lowboy and Highboy Unit Heaters

UNIT HEATERS of two new types, the Lowboy and Highboy, have recently been developed. The Lowboy consists of one section of paneled casing, while the Highboy is made up of two sections.

Considerable care has been exercised to keep the assembly simple and universal. Complete rotor and



LOWBOY HEATER INSTALLED WITH WALL BRACKETS

shaft are designed to be removed through end plates without disturbing top of fan casing or fan housing. Motor bracket end plate and outboard end plate are interchangeable, so that the drive can be placed on either end. The motor bracket can be revolved to any position of discharge.

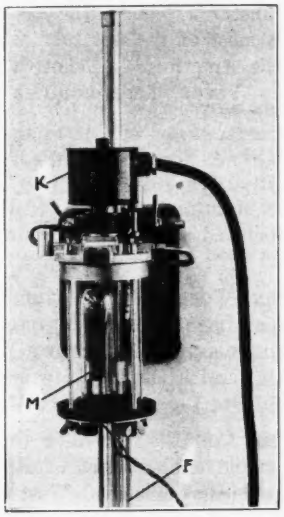
The heating element is made up of Universal Aerofin suitable for pressures from 2½ to 150 lb. gage. This heater element can be removed from either end of the unit through end plates. It can be assembled with steam or drip connections on either end as desired.

The multirotors are of the centrifugal type, each in its own fan housing, designed to deliver a large volume of air quietly and efficiently. The rotor is of the multiblade type, using a modified backward-tipped blade, designed to be positive in its air delivery and effectively to force the warm air over a large working area. Highboy and Lowboy heaters are designed by the Buffalo Forge Co., Buffalo, N. Y., for almost any space or structure.

Dissolved Oxygen Recorder for Boiler Feedwater

DISSOLVED OXYGEN in feedwater is often held responsible for corrosion of boilers and deaerating plants are frequently installed to keep the oxygen content down to a low figure. To eliminate the risk of the deaerated water picking up oxygen on its way to the boiler, it may be desirable to measure the amount of oxygen actually present in the water entering the boiler.

For making such measurements, the apparatus shown in the accompanying photograph has been designed for use where mechanical or evaporating types of deaerators are employed. A small quantity of the feedwater is passed at a constant rate through a tower F filled with extractor rings, where it is "scrubbed" by a constant flow of pure hydrogen generated in the electrolytic cell M. The hydrogen mechanically replaces the dissolved oxygen in the feedwater, and the displaced gas forms a considerable percentage of the total gas issuing from the top of the scrubber. This percentage is measured by a katharometer K of a similar design to a CO_2 meter produced by the patentees and is connected to a standard thread recorder, calibrated in cubic centimetres of oxygen per liter of water. The apparatus may be arranged to operate an electric alarm signal when the oxygen percentage rises above the critical figure. Single



INSTRUMENT FOR MEASURING DISSOLVED OXYGEN IN FEEDWATER

or multipoint recording, indicating or combined indicating and recording outfits are made, while the recorder can also be connected, if desired, to standard CO_2 and CO meters and to a thermo-couple placed in the boiler flue. Further information about this device can be obtained from F. G. Bailey, 127 Norbury Ave., Thornton Heath, Surrey, England.

COUNCIL OF THE American Society of Heating & Ventilating Engineers announces the appointment of Paul D. Close of Chicago to the newly created position of technical secretary of the Society for 1929. His work will include the compilation and editing of the text section of A. S. H. & V. E. Guide, reviewing of technical articles and meeting papers, coordination of data for preparation of Society codes and standards and work with Technical Committees of the Society. Mr. Close is a graduate of the University of Illinois and has been with the Johns-Manville Corp. and the Celotex Co.

CHICAGO ASSOCIATION OF CONSULTING ENGINEERS, at its Ninth Annual Meeting at the City Club, Chicago, on January 21, unanimously elected office for the ensuing year as follows: President, Ernest V. Lippe; vice-president, Rollo E. Gilmore; secretary-treasurer, H. L. Clute. The retiring president was Irving E. Brooks.

News Notes

At the annual convention of the A. S. H. & V. E. held in Chicago, January 28 to 31, announcement was made of the International Heating & Ventilating Exposition to be held in the Commercial Museum, Philadelphia, Pa., from Jan. 27 to 31, 1930, under the auspices of the A. S. H. & V. E. in conjunction with its annual meeting, which will be held during the same week in Philadelphia. The Exposition is to be managed by the International Exposition Co., Grand Central Palace, New York, to which all communications should be addressed.

Announcement has just been made by Heat Transfer Products, Inc., 90 West St., New York City, that it has become affiliated with the American Locomotive Co. All manufacturing will be done in the plants of the latter company. George T. Jacocks remains as manager of the Heat Transfer Products, Inc., and the company name as well as most of the key men will be retained. The offices of the American Locomotive Co. are at 30 Church St., New York, where inquiries should be addressed.

Cutler-Hammer, Inc., Milwaukee, Wis., announces that it has acquired the business of the Trumbull Vanderpoel Electric Manufacturing Co. of Bantam, Conn., which will be operated as a subsidiary under its present name.

Murray Iron Works Co., Burlington, Iowa, announces the appointment as sales representatives of the O. B. Davis Engineering Co., Brown-Marx Building, Birmingham, Ala., and Flickinger, Meyers and Rudolph, 129 West Second St., Los Angeles, Calif.

Bailey Meter Co., 1050 Ivanhoe Road, Cleveland, Ohio, announces the appointment of R. V. Knapp as manager of its Chicago office, 53 West Jackson Blvd., Chicago, Ill., C. M. Kunkel as manager of its Houston office at 1201 West Gray Avenue, Houston, Texas, and H. H. Gorrie as acting manager of its San Francisco office at 402 Sharon Building, San Francisco, Calif.

The Ric-wiL Co., Cleveland, Ohio, has just opened two new direct factory branch offices. One of these is in Chicago, Ill., at 724-725 Harris Trust Building, 111 West Monroe St., in charge of Ralph E. Sutherland, who handled the Ric-wiL business for the Stannard Power Equipment Co. and Fred G. Austin, formerly central station engineer with the Rochester Gas & Electric Co. at Rochester, N. Y. The second office is at Baltimore, Md., at 517 Garrett Building in charge of Louis G. Vance, formerly with Vance & Vance of that city.

American Hammered Piston Ring Co., Baltimore, Md., announces the resignation of W. C. Stettinius as president and general manager of the company. He will remain on the board of directors as vice-chairman of the board. Allen W. Morton, who has been vice-president of the company for the last three years has been elected president and general manager.

Hardy S. Ferguson announces that he has admitted Moses Hay Teaze, member A.S.M.E. and E.I.C. and James Wallace Tower, member A.S.M.E. and A.S.C.E., to partnership in the engineering business in which he is engaged. With these gentlemen, he will continue the practice of consulting engineering, under the name and address of Hardy S. Ferguson & Co., consulting engineers, 200 Fifth Avenue, New York City.

General Refractories Co. has recently opened an office at 742 Russ Building, San Francisco, Calif., in charge of W. E. Dornbach.

Griscom-Russell Co., New York City, has established an additional sales office at 433 Ellicott Square, Buffalo, N. Y.

Oesterlein Machine Co., Cincinnati, Ohio, announces the appointment on January 1 of R. W. Ott as sales manager.

C. F. Pease Co., Chicago, has established a new Pacific Coast Sales Office at 501 South Spring Street, Los Angeles, Calif., under the direction of Ralph S. Gibson, western sales manager.

Buckeye Machine Co., Lima, Ohio, announces that Frank C. Douglas has been appointed to its sales force. He will be located at St. Louis, Mo.

Homestead Valve Manufacturing Co., Corapolis, Pa., has appointed as its exclusive representative in the Birmingham, Ala. district, the Moore-Handly Hardware Co. of Birmingham, Ala. The account will be handled under the direct supervision of J. M. Bates.

Benjamin Shertenleib is leaving the Strand Hotel in Atlantic City to take the position of assistant plant superintendent of the Appalachian Power Co. at its central station in Logan, W. Va.

E. M. Herr, president of the Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa., announces that the company has taken over the assets of the R. D. Nuttall Co. as of January 1 and will carry on its operations as a branch of the Westinghouse Electric and Manufacturing Co. The Nuttall plant will be known as the Nuttall Works of the Westinghouse Electric & Manufacturing Co.

Oxweld Acetylene Co. has placed on the market a welding blowpipe, specially suited for light tube, sheet metal and aircraft welding. It is of injector type, weighs slightly over 9 oz., has seven interchangeable heads of various shapes and lengths and has a knurled handle to provide a good grip.

Frank H. Sprague has resigned as sales manager of the Skidmore Corp. and is now associated with George B. Burke, vice-president, Sarco Co., Inc., Engineering Building, Chicago, Ill. Mr. Sprague will act as sales manager of the Sarco Company's newly-created Western Heating Division.

Veeder-Root Incorporated, 1775 Broadway, New York, has consolidated its purchasing under J. M. Brown, the purchasing agent at the Hartford plant, Sargeant and Garden Streets, Hartford, Conn. B. W. Aspelin, formerly purchasing agent at the Bristol plant of the company, has accepted the position of purchasing agent for the Hartford Machine Screw Co.

Young Radiator Co., Racine, Wisconsin, is placing on the market a new type of large, heavy-duty radiator for unusually large Diesel engines and oil engines. This radiator has heavy structural sides, cast iron top

and bottom tanks designed for the strains to which it is subjected in use with excavators, draglines, shovels, oil field equipment and other work of this type. The units have a fan mounted directly on the radiator and the design of the core is intended to eliminate vibration and leakage. Tubes are extra large to permit passage of a large volume of water and eliminate clogging. The radiators are made in various capacities suitable for all sizes or makes of Diesel engines.

THE BOARD OF DIRECTORS of the Sullivan Machinery Co. has unanimously elected Arthur E. Blackwood of Chicago, president of the company, succeeding the late Frederick K. Copeland. Mr. Blackwood has been with the Sullivan Machinery Co. for the past 32 yr. He came to the company shortly after graduating at Toronto University as a mechanical and electrical engineer, and later became manager of its Eastern sales department with headquarters in New York, which office he held for 23 yr. He was then elected a director and first vice-president in charge of finances, and moved to the company's head office at Chicago, where he continued in close relation with Mr. Copeland until the latter's death in November of last year.

DOT LUBRICATION EQUIPMENT Co., Cambridge, Mass., has just appointed as its Intermountain representative, Urquhart Service, 509 Seventeenth St., Denver, Colo., of which M. B. Urquhart is manager.

ON THE GROUND that his continued ill-health does not warrant his again undertaking the arduous duties which the administration of the office involves, Arthur W. Thompson has presented to the executive committee his resignation as president of the United Gas Improvement Co., of Philadelphia, Pa. Filling of the vacancy in the office of president will not be considered for the present but the executive function will continue to be exercised by John E. Zimmermann, chairman of the executive committee.

GENERAL ELECTRIC Co. is sending out an offer to users of its equipment, offering renewal service in the way of a survey of plant, advice regarding renewal parts stock or bulletins of renewal parts. Requests to F. N. Thiltges, renewal part specialist, industrial department, General Electric Co., 230 South Clark St., Chicago, Ill., will secure this service.

BOILER ENGINEERING Co., 931 Federal Trust Bldg., Newark, N. J., announces that John D. Hiles, Oliver Bldg., Pittsburgh, Pa., has taken over the Pittsburgh territory, also that the Cleveland territory will in the future be handled by the Power Auxiliary Co., under the direction of H. F. Bauer.

CHICAGO PUMP Co., Chicago, Ill., has recently appointed the following new representatives: Ace Combustion & Engineering Co., 222 Milan St., Shreveport, La.; F. L. Bunker, P. O. 1223, Greensboro, N. C.; L. Brandenberger, 149 W. 2nd St., South, Salt Lake City, Utah; J. J. Smith, 3620 Ednor Road, Baltimore, Md.

THOMAS E. MURRAY, INC., has moved its New York office to 88 Lexington Ave., where it occupies the entire 8th floor of the American Book Co.'s new building, at the corner of 26th St. It has also opened an office in the Eaton Tower Building, Detroit, Mich. For a long time the company was located at the old 55 Duane Street Building which contains the historical Edison power plant. Thomas E. Murray, president of the company, and for many years general manager, senior vice-president and vice-chairman of the board of directors of the New York Edison Co., and an official and director of several other utility companies, has recently severed these connections and intends to devote his time to Thomas E. Murray, Inc., and to the development of his patents.

ALLIS-CHALMERS MANUFACTURING Co., Milwaukee, Wis., announces that it has enlarged its stock of Texrope drives up to 50 hp., including all the popular motor speeds, with a large choice of driven speeds in a range of ratios from 1:1 up to 7:1.

L. R. KING, for nearly 17 yr. associated with the United Light & Power Co., Davenport, Iowa, and the last 5 yr. rate and appraisal engineer, has been appointed assistant general manager of the United Light and Power Co. and its construction subsidiary, the United Light and Power Engineering and Construction Co. He will maintain his headquarters in the main building in Davenport. He will continue his duties in the rate and appraisal department in addition to his post as assistant general manager.

PLANS FOR consolidation have been arranged by the City Ice and Fuel Co., Cleveland, Ohio, and the Continental Ice Co., Chicago, Ill. The City Ice and Fuel Co. will be active in the management of all properties of the Continental company, including plants at Chicago, Clinton, Ohio, Manchester, Maybrook and Mechanicsville, N. Y. Work is now under way for the construction of new ice and coal storage plants at Oakwood, near Detroit, Mich., and at Port Huron, Mich. The two latter plants will be equipped for capacities of about 1800 t. a day.

CONTROLLING STOCK interest in the Newport Electric Light Co. of Newport, Vt., has been sold to W. B. Foshay Co. of Minneapolis, Minn., it has been announced by the Orleans Trust Co., of Newport. The present corporate name will be retained but the property will probably be merged with Public Utilities Vermont Corp., a subsidiary of the Public Utilities Consolidated Corp., which is the holding and operating company for the Foshay interests. Acquisition of the Newport Electric Light Co. gives the Foshay Co. control of all of the hydroelectric power developments and undeveloped sites on the Clyde River with the exception of the generating plant belonging to the Village of Barton.

WISCONSIN PUBLIC SERVICE CORP., Milwaukee, Wis., a subsidiary of the Byllesby Engineering & Management Corp., Chicago, Ill., has plans under way for the construction of an artificial gas plant at Sheboygan, Wis., reported to cost about $700,000.

IN A RECENT ADDITION to the Durant Automobile Co. plant at Lansing, Mich., four new Union 500-hp. boilers have been installed to augment the previous installation of four 300-hp. boilers of the same make. The new units are fired by Detroit, forced-draft underfeed stokers and have Copes feedwater regulators.

Two Union centrifugal boiler feed pumps, driven by Elliott turbines, a Worthington open heater and an

Alberger high-pressure heater, two forced-draft fans driven by Engberg steam engines, Penberthy injectors for emergency boiler feed and a 2500-c.f.m. Ingersoll-Rand air compressor complete the new equipment.

This plant, which was designed by the Durant engineering department, has a complete installation of Republic flow meters and it is expected that an automatic combustion control will be added later. H. H. Barnes is plant engineer and H. Anderson, chief operating engineer.

Eastern New Jersey Power Co., Asbury Park, N. J., is reported to be arranging for bids for its proposed steam power station on the site recently acquired at Sayreville, N. J., the project being reported to cost about $4,000,000 with transmission system. The Management & Engineering Corp., 320 So. La Salle St., Chicago, Ill., is engineer for the project.

Delaware, Lackawanna & Western Railroad Co., 90 West St., New York, is asking bids for the proposed electrification of its suburban lines at Newark, Orange, Summit, Morristown, N. J. and vicinity. This is to consist of overhead system using direct current at 3000 v. and involving an expenditure of about $10,000,000 for track, rolling stock and distribution equipment. Negotiations are under way with the Public Service Electric & Gas Co., Newark, for power supply and if this cannot be arranged, it is proposed to construct a power plant on the Hackensack River on the outskirts of Jersey City, N. J. The engineering department of the railroad is in charge of the project.

Illinois Light and Power Co. has been granted authority by the Illinois Commerce Commission to construct a hydroelectric plant in the Kankakee River near Ritchie, Ill., to be completed by Jan. 1, 1930. The utilities company petition cited that power would be provided for industries of the community and sold to the Illinois Central Railroad for operation of its electric lines. The commission ordered the Illinois Light and Power Co. to reach agreement with the Will and Kankakee County boards, which had objected to the permit, upon protection of the county line bridge from inundation from the back water.

Duquesne Light Co., Pittsburgh, Pa., has awarded contracts for the primary equipment for initial unit of the proposed James H. Reed power plant at Brunot Island, for which ground was recently broken. The Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., is to furnish a 60,000-kw. turbine generator with auxiliaries; the Babcock & Wilcox Co., New York, is to furnish water-tube boilers, economizers and other auxiliaries and the stokers are to be supplied by the Westinghouse Co. The new plant is scheduled for completion during the summer of 1930. The present program calls for the installation of another 60,000-kw. turbine generator to be placed in operation in 1932, with a third similar unit 2 yr. later.

Sioux City, Iowa, Gas and Electric Co. has occupied its newly remodeled central office headquarters in the Utilities Building, 517 Fifth St., combining in this structure the departments and executive headquarters formerly divided between the Commerce and Frances buildings. W. J. Bertke, general manager of the gas and electric company and E. L. Kirk, general manager of the Sioux City Service, head the two principal divisions of the utilities.

Public Service Co. of Colo., Gas and Electric Building, Denver, Colo., is planning a general expansion program for 1929 to cost about $2,000,000. It is proposed to develop hydroelectric power in the vicinity of Boulder Canon and Georgetown, with an initial installation to cost about $300,000. At Boulder it is planned to make extensions in the existing steam power plant, including the addition of two boiler units, chimney and so on. An addition is planned to the power station in the north-east section of Denver to cost about $500,000 with equipment. Clare N. Stannard is vice-president.

Public Service Electric & Gas Co., Newark, N. J., has authorized preliminary surveys for a proposed electric generating plant on Arthur Kill near Sewaren, N. J., where a tract of 125 acres of land was recently acquired. It is intended that the plant will have a unit capacity of 1,000,000 kw. The time of construction is still indefinite and work may be deferred for several months, during which period subsoil studies and preliminary developments will be carried out. In connection with this project, the company proposes an extensive transmission system to tie in with its present plants at Kearny, Jersey City and Newark, and to connect with the system of the Philadelphia Electric Co. which will cross the state to furnish wholesale power from its Conowingo hydroelectric plant.

Lincoln Electric Co. of Cleveland, Ohio, has advanced J. E. Durstine to district sales representative for the southeast territory with headquarters at Birmingham, Ala. H. P. Egan has also been promoted to district sales representative for central Ohio with headquarters at Columbus.

Narragansett Electric Co., Providence, R. I., is planning an expansion program involving an expenditure of about $1,500,000 for additional generating equipment and accessories.

San Antonio Public Service Co., San Antonio, Texas, is planning an expansion program involving about $4,000,000. Of this amount, about $1,000,000 will be for the completion of the second unit at the New Braunfels plant, comprising a 30,000-kw. installation. W. B. Tuttle is president.

Books and Catalogs

Mechanical World Year Book, 1929 edition; Emmet & Co., Ltd., 65 King St., Manchester, Eng.; 348 pages, illustrated; cloth, 4 by 6; price, 1s6d.

This is the 42nd year of publication of the Mechanical World Year Book and following their usual practice, the publishers have introduced several new sections in the 1929 edition. Among these is a lengthy contribution on helical springs in which it is endeavored to eliminate many of the troublesome calculations usually necessary. Another new section gives notes and data on flywheel proportions, while another deals with compressed air. Tables have been introduced on mild steel, wire ropes for cranes and valve rod ends. Additions have been made to the section on belt conveyors and various revisions have been effected in other sections. For the rest, the book is a compilation of valuable tables

and discussion of practically all phases of mechanical engineering and should be of the highest value to all engineers. Although the book itself is pocket size, the type is easily read, the illustrations are clear and to the point and, while many of the data apply especially to British practice, they are equally useful in this country.

EXHAUST STEAM ENGINEERING, by Charles S. Darling; 6 by 9 in., 430 pp., 214 illustrations; John Wiley & Sons, Inc., 1929; cloth, $7.50 net.

As stated by the author, his object was to cover the problems associated with the choice of machinery and the disposition of power plant from the point of view of the user and the consulting engineer. He states that much can be done not only with the new plant but also with the old one to improve coal consumption and reduce costs.

In the first four chapters, devoted to cycles of operation, thermodynamics, and the regenerative cycle, principles are discussed and worked out mathematically. Comparison is made of the thermal and financial economy of heating alone with heating and power for various conditions; of various ways of utilizing exhaust steam; of regenerative heating of feedwater and steam by bled steam and live steam and discussion given of the economic limits of bleeder heating.

In the balance of the book, 18 chapters, practice in plant is treated covering the place of auxiliaries in plant heat balance, the economics of utilizing steam at back pressure and of reheating steam, the use of bleeder or "pass-out" turbines and engines, applications of the steam accumulator, methods of steam distribution and the effect of capital expenditure and fixed charges on industrial power costs.

Perhaps the most valuable feature is the treatment of steam accumulator practice and possibilities to which five chapters of 84 pages are devoted.

On the whole, the book is a complete and thoughtful treatment of the subject giving much new data and a clear comprehension of the proper method of going about the solution of any problem which may be met as to the utilizing of exhaust steam economically. Wisely, the author does not set forth dogmatic conclusions or rule-of-thumb methods for solving such problems.

REPORT of the subcommittee on pipe joints of American Gas Association, Inc., by O. S. Hagerman, chairman, gives results of tests on the strength of oxy-acetylene welded pipe joints of many kinds and details of procedure control for making such joints, as well as headers and fitting attachment, appendices treat of templet layouts for special constructions. Conclusions as to results are that a properly made oxy-acetylene welded joint is as strong as the pipe; that the simple butt-welded joint is the most efficient; that nearly as good results were obtained with socket and socket with groove joints; that there is no heat weakening of the pipe due to welding; that with procedure control and properly made welds, uniformly high strength and dependability can be attained. Copies of the report can be had from the association, 420 Lexington Ave., New York, N. Y.

REPRINT of a paper entitled Lignite as a Commercial Fuel, by Edward P. Price, which won the second prize award before the N. E. L. A., is being distributed by Combustion Engineering Corp., 200 Madison Ave., New York. It contains valuable information on the use of lignite in pulverized form and describes experiences in the use of this fuel in Trinidad station of the Texas Power & Light Co., and the Comal Power Co.'s plant at New Braunfels, Texas. Copy may be secured on request to the Combustion Engineering Corp.

BULLETIN No. 13 on Nickel Steel data and applications treats of torsion impact and other mechanical properties of nickel-chrome steel, showing the results of tests made in the laboratories of the International Nickel Co., 67 Wall St., New York, N. Y., from whom the bulletin may be obtained on request.

WELDED pressure vessels, their advantages and the possibilities of this method of manufacture are described and illustrated in Bulletin No. 507 issued by A. O. Smith Corp. of Milwaukee, Wis.

IN AN ATTRACTIVELY ILLUSTRATED, twenty-four-page bulletin, No. 1228, the Hydrojet system of ash removal is described in detail, together with other products of the Allen-Sherman-Hoff Co., Philadelphia, Pa. Ash pumps, portable clinker grinders and new designs of the Hydrojet for stoker fired furnaces and details of application of the system to many conditions are presented.

SHAW-PERKINS MANUFACTURING Co., Pittsburgh, Pa., in a four-page illustrated folder describes Oval Tube Air Heaters for preheating combustion air for industrial, heating, drying and other purposes.

DUAL CLEARANCE, una-flow engines of the heavy-duty type are described and illustrated in bulletin No. 20 by the Harrisburg Foundry & Machine Wks., Harrisburg, Pa.

VIBRATION PROBLEMS IN ENGINEERING, by S. Temoshenko; published by D. Van Nostrand Co., 8 Warren St., New York, N. Y.; 346 pages; price, $4.50.

Fundamentals of the theory of vibration are developed and their application to the solution of technical problems illustrated by examples taken largely from actual experience. The book is largely mathematical and, to the average engineer, the appendix giving a general dimension and description of vibration measuring instruments will be the most interesting, although the chapters dealing with turbine blade, disk and shaft vibration sum these problems up in a comprehensive manner which will be appreciated by one familiar with calculus.

ADVANTAGES of measuring boiler blowoff with the V-notch recorder are discussed, together with a description of the recorder itself and a description of the combined blowoff tank and meter, in a four-page folder just issued by Cochrane Corp., 17th St. and Allegheny Ave., Philadelphia, Pa.

FINDING AND STOPPING WASTE IN MODERN BOILER ROOMS; published by the Cochrane Corp., Philadelphia, Pa.; third edition, 780 pages; price, $3.00.

This is a well-edited, up-to-date handbook of boiler room practice for the boiler plant designer, executive and operator. It is divided into five sections, covering fuels, combustion, heat absorption, boiler efficiency and testing and feedwater heating and conditioning. Advantage was taken of the necessity of resetting the type to introduce considerable new matter, particularly in connection with the heat balance and boiler feedwater and to revise the other sections.

Power Plant Construction News

Ala., Anniston—The Alabama Coca-Cola Bottling Co., Anniston, contemplates the installation of power equipment in proposed new plant on South Noble Street, entire project reported to cost close to $100,000.

Calif., Salinas—The Salinas Valley Ice Co., Salinas, is considering the construction of an ice-manufacturing plant on 65-acre tract of land, in the vicinity of Chualar, recently acquired, with initial capacity of about 125 tons per day, reported to cost in excess of $100,000, with machinery.

Calif., South Gate—The Samson Tire & Rubber Co., 733 East Eighth Street, Los Angeles, has approved plans for a new plant at South Gate, to cost in excess of $400,000, and will install considerable power equipment; project will include a boiler house, pumping plant, and other mechanical units. Morgan, Wall & Clements, Van Nuys Building, are architects.

Colo., Denver—The Gates Rubber Co., 999 South Broadway, plans installation of power equipment in a four-story plant unit to cost about $125,000. John M. Gardner and Eugene F. Evans, 1342 Broadway, are architects.

Fla., Avon Park—The Florida Public Service Co., Orlando, is perfecting plans for the construction of an ice-manufacturing and precooling plant at Avon Park, with initial capacity of about 40 tons per day, reported to cost close to $65,000.

Fla., Mayport—The Mayport Fisheries Co., Inc., care of Charles S. Wallace, Moorehead, N. C., recently formed by Mr. Wallace and associates, plans installation of power equipment in proposed fertilizer and fish oil plant at Mayport, entire project to cost more than $125,000.

Ill., Chicago—C. O. Sephness, care of Ronneberg & Pierce, 10 South La Salle Street, architects, will install power equipment in new two-story chemical manufacturing plant at Belle Plaine and Kilpatrick Avenues, project to cost more than $200,000. Architects noted are in charge.

Ill., East Peoria—The Caterpillar Tractor Co. will install power equipment in proposed addition to local plant reported to cost close to $1,000,000. Headquarters are at Oakland, Calif. M. M. Baker is manager at East Peoria.

Ill., Monmouth—The Western Stoneware Co. plans installation of power equipment in connection with proposed rebuilding of Plant No. 2, recently destroyed by fire with loss reported in excess of $100,000.

Ind., Richmond—Plans are being considered for extensions and improvements in the municipal electric light and power plant on South Eighth Street, reported to cost close to $400,000; a new turbo-generator and auxiliary equipment will be installed. John Graham is chief engineer.

Iowa, Clarion—The Municipal Utilities Co., 526 Liberty Boulevard, Des Moines, Iowa, will have plans drawn at once for an electric light and power plant at Clarion to cost about $150,000, with equipment. A franchise has been secured.

Ky., Covington—The Cambridge Tile Mfg. Co., Sixteenth and Woodburn Streets, Covington, plans installation of power equipment in a new plant unit to cost more than $450,000. Burt L. Baldwin, Second National Bank Building, Cincinnati, Ohio, is engineer. John C. Herman is secretary.

La., Monroe—The Brown Paper Mill Co. is said to be planning installation of power equipment in proposed addition to plant, project to cost close to $100,000, with equipment.

Md., Baltimore—The Berliner-Joyce Aircraft Co., care of Henry Berliner, head of the Berliner Aircraft Co., Alexandria, Va., recently formed by Mr. Berliner and associates, plans installation of power equipment in new aircraft plant at Baltimore, for which site has been secured, entire project to cost about $200,000.

Mass., Cambridge—John Morrell & Co., 75 Commercial Street, Boston, plans installation of power equipment and cold storage apparatus in proposed new meat-packing plant at Cambridge, reported to cost close to $100,000. Headquarters are at Ottumwa, Iowa. Henschein & McLaren, 1637 Prairie Avenue, Chicago, Ill., are architects.

Mass., Everett—The Edison Electric Illuminating Co., Boston, is reported planning new steam-operated electric generating plant on tract of about 35 acres of land on the Mystic River, Everett, recently acquired, to cost more than $1,500,000, with equipment. Extensions will be made in transmission lines.

Mass., Worcester—The Board of Trustees, Worcester Polytechnic Institute, is planning construction of a mechanical engineering building and laboratory on the campus, reported to cost more than $300,000.

Mich., Dowagiac—The Sterling Ice Co. is said to be planning construction of an addition to ice-manufacturing plant to cost close to $55,000, with equipment. M. E. McGurn is secretary.

N. C., Washington—The Phillips Fertilizer Co. is said to be planning the installation of power equipment in a proposed new plant addition, entire project reported to cost close to $70,000.

N. J., Linden—The Warner-Quinlan Co., 2 Park Avenue, New York, plans installation of power equipment, including pumping machinery, in connection with proposed rebuilding of asphalt refinery near Linden, destroyed by fire, Feb. 12, with total loss reported at close to $100,000.

N. Y., Brooklyn—Palmer Brothers, Inc., 112 Front Street, plans installation of power equipment in connection with proposed rebuilding of portion of electric appliance manufacturing plant, destroyed by fire, Feb. 14, with total loss reported at close to $100,000.

N. Y., Iona Island—The Bureau of Yards and Docks, Navy Department, Washington, D. C., will receive bids until March 20, for motor-driven pumps, hydrants, valves and accessories, in connection with extensions in water system at the Naval Ammunition Depot, Iona Island, as per Specification 5681. Also, at the same time, for two steel water tanks at same location, as per Specification 5682.

Ohio, Akron—The Columbia Silica Co. is said to be planning the installation of power equipment in connection with proposed rebuilding of portion of plant about six miles from Akron, destroyed by fire, Feb. 12, with loss reported at close to $100,000.

Ohio, Springfield—The Central Brass & Fixture Co. plans installation of power equipment in connection with proposed rebuilding of portion of plant destroyed by fire, Feb. 14, with total loss reported in excess of $100,000.

Okla., Roxana—The Shell Petroleum Corporation, Shell Building, St. Louis, Mo., plans installation of power equipment in proposed rebuilding of portion of oil refinery at Roxana, destroyed by fire, Feb. 8, with total loss reported at close to $150,000.

Pa., Bethlehem—The Bethlehem Milling Co. plans installation of power equipment in proposed additions to flour mill, entire project reported to cost more than $350,000.

Pa., Philadelphia—The Ford & Kendig Co., Twenty-fourth and Wood Streets, plans installation of power equipment in proposed new iron and metal-working plant at Fifty-sixth Street and Elmwood Avenue, entire project reported to cost more than $300,000.

Texas, Eagle Pass—The Maverick County Water Improvement District, No. 1, Eagle Pass, has been authorized at a special election to arrange a bond issue of $1,800,000, for a hydroelectric power plant and irrigation project, for which plans will be prepared at an early date.

Texas, Sweetwater—The Gulf Refining Co., Frick Annex, Pittsburgh, Pa., plans installation of power equipment in proposed oil refining plant near Sweetwater, entire project reported to cost more than $1,000,000. It is scheduled for completion by the end of the year.

Wash., Aberdeen—The Consolidated Plywood & Lumber Co., Aberdeen, G. A. McChesney, manager, plans construction of one-story power house at proposed new lumber mill on the Elliott waterway, entire project to cost more than $125,000.

Wis., Waukesha—The Manitowoc Church Furniture Co., 1214 Lincoln Avenue, is considering extensions and improvements in power plant, including installation of additional equipment. C. F. Schuetze is one of heads of company in charge.